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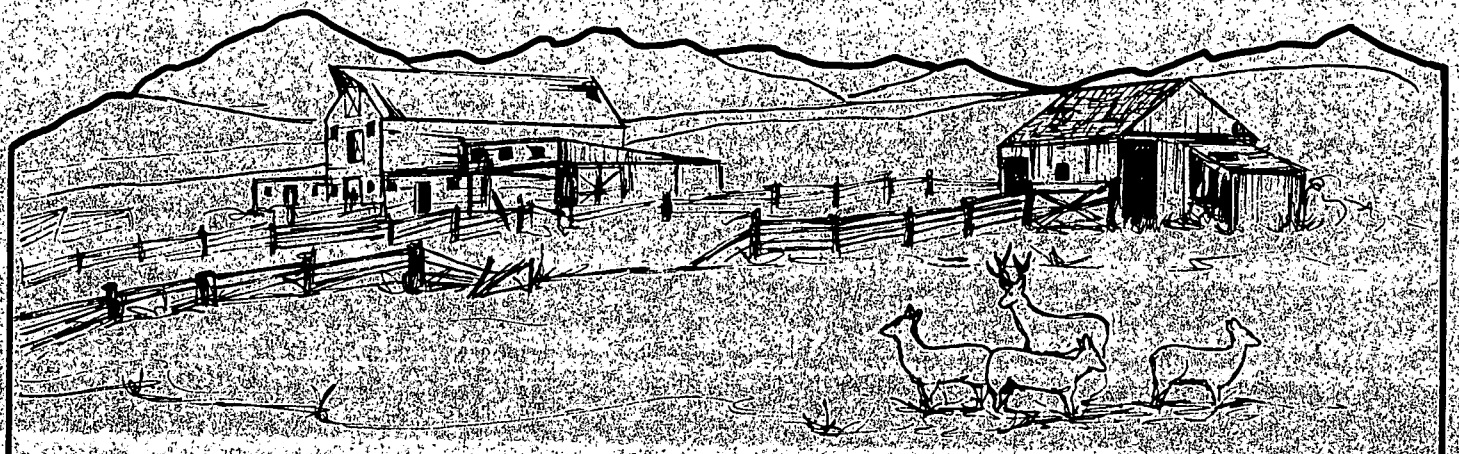

ANNUAL ENVIRONMENTAL MONITORING REPORT

JANUARY-DECEMBER, 1983

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Energy Systems Group
Rocky Flats Plant

UNITED STATES DEPARTMENT OF ENERGY
ADMINISTRATION CONTRACT DE-AC04-76DPO3533

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APPENDIX E

REPORTING OF MINIMUM DETECTABLE CONCENTRATION AND ERROR TERMS

Throughout the section entitled "Monitoring Data: Collection, Analyses, and Evaluation" in this report, some of the concentrations that are measured at or below the minimum detectable concentration (MDC) are assigned the MDC value. The less-than symbol (<) indicates MDC values and calculated values that include one or more MDC's.

The plutonium, uranium, americium, and beryllium measured concentrations are reported. These reported concentrations include values that are less than the corresponding calculated MDC's and in some cases, values less than zero. Negative values result when the measured value for a laboratory reagent blank is subtracted from an analytical result that was measured as a smaller value than the reagent blank.

Error terms in the form of a ± b are included with some of the data. For a single sample, "a" is the reagent-blank corrected value; for multiple samples it represents the average value (arithmetic mean). The error term "b" accounts for the propagated statistical counting uncertainty for the sample and the associated reagent blanks at the 95 percent confidence interval. These error terms represent a minimum estimate of error for the data. Other analytical and sampling errors are being investigated for future incorporation into an all-inclusive error term for each value.

Ninety-five percent confidence limits for the plutonium concentrations in ambient air have been derived using Fieller's Theorem.[24] These limits consist of a Lower Confidence Limit (LCL) and an Upper Confidence Limit (UCL) on each point estimate for the various concentrations. The calculation of the limits requires knowledge of the analytical error term "b" as described above, and in addition, the variance of the air volume measurement associated with a specific sample. These variances are calculated from the data reported as part of a routine flow measurement calibration program for ambient air samplers. Bias errors and temperature coefficients of the sampler readout devices are also statistically computed, and the individual readout devices are individually corrected for those factors.

TABLE D-2. Detection Limits for Radioactive and Nonradioactive Materials

Legend

μCi	= microcuries	pCi	= picocuries
μg	= micrograms	mg/ℓ	= milligrams per liter
m^3	= cubic meters	SU	= standard units
mℓ	= milliliters	NTU	= Nepholometer turbidity units

Parameter	Approximate Detection Limit (per sample)	Approximate Sample Volume Analyzed[a]	Approximate Minimum Detectable Concentration
Airborne Effluent Samples			
Plutonium 239, 240	1.0×10^{-7} μCi	3,200 m^3[b]	0.03×10^{-15} μCi/mℓ
Uranium 233, 234, 238	2.0×10^{-7} μCi	3,200 m^3[b]	0.06×10^{-15} μCi/mℓ
Tritium	5.0×10^{-6} μCi	0.06 m^3	$83{,}000 \times 10^{-15}$ μCi/mℓ
Beryllium	1.0×10^{-3} μg	128 m^3[b]	8×10^{-6} μg/m^3
Ambient Air Samples			
Plutonium 239, 240	1.0×10^{-7} μCi	20,000 m^3[c]	0.005×10^{-15} μCi/mℓ
Effluent Water Samples (Radioactive)			
Plutonium 239, 240	1.0×10^{-7} μCi	5,000 mℓ	0.02×10^{-9} μCi/mℓ[c]
Uranium 233, 234, 238	2.0×10^{-7} μCi	1,000 mℓ	0.2×10^{-9} μCi/mℓ
Americium 241	1.0×10^{-7} μCi	5,000 mℓ	0.02×10^{-9} μCi/mℓ[c]
Tritium	2.5×10^{-6} μCi	5 mℓ	500×10^{-9} μCi/mℓ
Soil Samples (Radioactive)			
Plutonium 239, 240	1.0×10^{-7} μCi	10 g	10.0×10^{-9} μCi/g
Effluent Water Samples (Nonradioactive)			
pH		Not Applicable	0-14 SU
Nitrate as N		10 mℓ	0.2 mg/ℓ
Total Phosphorus		50 mℓ	0.2 mg/ℓ
Biochemical Oxygen Demand, 5-Day		10 mℓ	1.0 mg/ℓ
Suspended Solids		100 mℓ	1.0 mg/ℓ
Total Chromium		5 mℓ	0.05 mg/ℓ
Residual Chlorine		10 mℓ	<0.1 mg/ℓ
Oil and Grease		500 mℓ	0.1 mg/ℓ
Fecal Coliform Count		10-100 mℓ	1 organism/100 mℓ
Turbidity			30 NTU
Color			30 units

a. Volume analyzed is usually an aliquoted fraction of the total sample volume collected.
b. Monthly composite.
c. Two-week composite.

TABLE D-1. (Concluded)

Legend

A_{ri} = Non-blank corrected activity of laboratory reagent blank for isotope i, expressed as picocuries per unit volume.

a_{ri} = Non-blank corrected uncertainty of laboratory reagent blank, expressed as picocurie per unit volume.

A_{si} = Sample activity for isotope i, expressed as picocurie per unit volume.

a_{si} = 95 percent confidence level uncertainty of a sample, expressed as picocurie per unit volume.

B_{si} = Blank corrected sample activity for isotope i, expressed as picocurie per unit volume.

b_{si} = Blank corrected sample uncertainty, expressed as picocurie per unit volume.

C_{Bi} = Detector background gross counts for isotope i.

C_{Bj} = Detector background gross counts for internal standard isotope j.

C_{si} = Sample gross counts for isotope i.

C_{sj} = Sample gross counts for internal standard isotope j.

D_{sj} = Activity (disintegrations per minute) of internal standard isotope j added to sample.

E_s = Absolute detection efficiency for sample detector.

L_{si} = Sample minimum detectable activity (MDA) for isotope i, expressed as picocurie per unit volume.

T_B = Detector background count time expressed in minutes.

T_s = Sample count time expressed in minutes.

V = Sample unit volume or sample unit weight.

Y = Chemical recovery for sample.

TABLE D-1. Formulae for Activity and Uncertainty Calculations for the Alpha Spectral Analysis Systems

Non-Blank Corrected Sample Uncertainty

$$a_{si} = \frac{1.96\, A_{si}}{V \cdot 2.22} \left[\frac{\frac{C_{si}}{T_s^2} + \frac{C_{Bi}}{T_B^2}}{\left(\frac{C_{si}}{T_s} - \frac{C_{Bi}}{T_B}\right)^2} + \frac{\frac{C_{sj}}{T_s^2} + \frac{C_{Bj}}{T_B^2}}{\left(\frac{C_{sj}}{T_s} - \frac{C_{Bj}}{T_B}\right)^2} \right]^{1/2}$$

Blank Corrected Sample Uncertainty

$$b_{si} = (a_{si}^2 + a_{ri}^2)^{1/2}$$

Non-Blank Corrected Sample Activity

$$A_{si} = \left[\frac{\frac{C_{si}}{T_s} - \frac{C_{Bi}}{T_B}}{\frac{C_{sj}}{T_s} - \frac{C_{Bj}}{T_B}} \right] \cdot \frac{D_{sj}}{V \cdot 2.22}$$

Blank Corrected Sample Activity

$$B_{si} = A_{si} - A_{ri}$$

Minimum Detectable Activity Calculation

$$L_{si} = \frac{4.66}{Y \cdot E_S \cdot V \cdot 2.22} \left[\frac{C_{Bi}}{T_S T_B} + \left(\frac{a_{ri} \cdot E_S}{1.96}\right)^2 \right]^{1/2}$$

(continued)

APPENDIX D
DETECTION LIMITS AND ERROR TERM PROPAGATION

The Rocky Flats Health, Safety and Environmental Laboratories (HS&EL) have adopted the following definition for detection limit, as given by Harley.[23]

> "The smallest amount of sample activity using a given measurement process (i.e. chemical procedure and detector) that will yield a net count for which there is confidence at a predetermined level that activity is present."

Making a reasonable estimate of the Minimum Detectable Activity (MDA) for a given radiochemical and counting procedure is complicated by the need to consider each of the following:

1. Detector background
2. Detector counting efficiency
3. Count time
4. Sample volume
5. Analytical blank
6. Type and amount of error allowable
7. Chemical yield or recovery for all steps within the process

Since 1980, several significant changes have affected the manner in which the HS&EL calculate MDA. The changes were made to more realistically represent the sensitivity of the various analyses. These changes increased the calculated MDA reported by the laboratories; however, this does not indicate an increase in the activity level of the samples analyzed.

Because of the low activity of samples analyzed by the HS&EL, negative results are occasionally reported. This is to be expected of samples that have activity levels below their calculated MDA values, especially as the true activity present approaches zero. The primary cause for negative values is low count rate. When a sample in this low count rate is analyzed, the sample may have fewer counts than the average blank for the sample and analysis type. In addition, the sample may have the same or fewer counts than the background value for the detector upon which the sample is counted.

Table D-1 shows the various formulae used for alpha data reduction during 1983.

Table D-2 shows the typical MDA values for the various analyses performed by the HS&EL and by the General Laboratories. These values are based on an average sample volume, typical detector efficiency, detector background, count time, and chemical recovery. MDA values calculated for individual analyses may vary significantly depending on actual sample volume, chemical recovery, and analytical blank used.

fluoroacetone (TTA) complex onto a planchet for pulse height analysis of the alpha energy spectrum.

Water samples to be tested for chemical and physical parameters are analyzed within 24 hours of collection, or they are preserved by refrigeration, freezing, or addition of a chemical preservative when required. The tests performed include gravimetric, titrametric, colorimetric, chromatographic, or electroanalytic methods, following procedures specified in the 15th edition of Standard Methods for the Examination of Water and Waste Water, EPA-600/4-79-020, or other authoritative publications.

Water samples to be analyzed for dissolved metallic ions are filtered through a 4.5-micron filter and evaporated onto a graphite electrode for emission spectrographic analysis. Selected elements are determined for sample solutions by atomic absorption methods after appropriate chemical treatment to prepare the proper analysis matrix.

Organic toxic species are determined by chromatography, following extraction into an appropriate organic solvent or onto a solid resin, using flame ionization, electron capture, or ultraviolet detection. Some organics, such as phenol, are determined by developing a chromaphoric complex and measuring light absorption at a specific wavelength with a spectrophotometer. Measuring occurs after extraction into an appropriate solvent phase.

Tritium is determined by intimate mixing of 5 milliliters of aqueous sample (or of water that has equilibrated with the sample for a predetermined time to ensure exchange) with 17 milliliters of scintillation cocktail. The mixture is counted for 20 minutes in a scintillation well, and an appropriate factor is applied to account for measuring quenching effects determined *in situ* for each sample.

Cesium, radium, and strontium isotopes are chemically separated from the sample matrix using precipitation techniques. The isotopes are either deposited on planchets with a carrier element for alpha or beta gas proportional counting, or (for radium 226) counted directly measuring the radon 222 emanation in a scintillation well by using a Lucas gas collection cell.

stack effluent samples. Five mℓ of the sample are combined with 17 mℓ of liquid scintillation cocktail mixture. Environmental samples are counted for 20 minutes and airborne effluent samples are counted for 4 minutes. All samples are counted at least twice.

The General Laboratory routinely performs the following analyses for environmental monitoring of Plant effluent streams, process wastes, and soil residues:

1. Dissolved metallic elements including tests for 31 cations by emission spectroscopic techniques, and 17 elements by atomic absorption techniques (including beryllium in airborne effluent sample filters).

2. Oxygen demand tests, including total organic carbon, dissolved oxygen, chemical oxygen demand, and biological oxygen demand (5-day incubation).

3. Nutrient tests including free ammonia and amines, ortho and total phosphate phosphorus, nitrate and nitrate anions, Kjeldahl nitrogen, and total nitrogen.

4. Physical tests, including pH, conductivity, color, total dissolved solids, suspended solids, turbidity, and specific gravity.

5. Soap residues (as alkyl sulfonate).

6. Oil and grease residues, by extraction and infrared or gravimetric detection, and by visual observation.

7. Specific chemical species, including total hardness (as calcium carbonate), alkalinity (as hydroxide, bicarbonate, or carbonate), chloride, fluoride, cyanide, sulphate, and hexavalent chromium.

8. Radioactive species, including gross alpha and beta by gas proportional detection; tritium by liquid scintillation detection; radium, cesium 134, and strontium 89 or 90 by gravimetric separation followed by gas proportional detection. Isotopes of plutonium, americium, thorium, uranium, neptunium, and curium are determined by ion exchange and liquid extraction techniques followed by alpha pulse height analysis.

9. Organic toxic species, including Bromacil, Endrin, Lindane, methoxychlor, toxaphene, phenol, polychlorinated-biphenyls, 2,4-D, 2,4,5-TP Silvex, and total organic halogen.

Procedures for these analyses were developed by the General Laboratory professional technical staff. Procedures were adopted from EPA-approved sources or from other recognized authoritative publications where EPA-approved procedures were not available. Laboratory operational procedures are documented in a standard format, approved by the manager of the Rocky Flats Analytical Laboratories, and distributed to a controlled distribution list to assure that proper testing and approval is performed before changes are adopted. The General Laboratory Quality Assurance Plan requires annual review of procedures for consistency with state-of-the-art techniques and compliance of lab practice with written procedures. In addition, a review is performed whenever an analytical problem is indicated.

The following is a general outline of the analysis procedures followed by the General Laboratory:

Liquid samples received for gross alpha and beta screening are evaporated directly onto planchets for gas proportional counting within 24 hours of collection. When activities exceeding action guidelines set by Environmental Analysis (EA) are observed, notification to EA is made, and re-analysis is begun immediately for verification. For some liquids such as machine oils, a specified volume is evaporated and the residue is taken up in dilute nitric acid for deposit onto the counting planchet. An appropriate factor is applied to account for self-absorption effects determined for each sample.

Liquid and solid samples submitted for alpha spectral pulse height analysis are analyzed in a manner similar to procedures followed by HS&EL. Chemical separation of elements is followed by deposition of an organic extract of 2-thenoyltri-

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APPENDIX C
ANALYTICAL PROCEDURES

The Health, Safety and Environmental Laboratories (HS&EL) routinely perform the following analyses on environmental and effluent samples:

1. Gross Alpha
2. Gross Beta
3. Gamma Spectral Analysis
4. Alpha Spectral Analysis (Pu-239, -238, Am-241, U-238, -233, -234)
5. Beta Liquid Scintillation - Tritium
6. Iodometric Titration - Chlorine
7. Bacteria
8. Atomic Absorption - Beryllium

Procedures for these analyses are described in the HS&EL Procedures and Practices Manual.[22] The procedures for bacteria and chlorine analyses were developed following EPA guidelines. Soil procedures were developed following specifications set forward in "Measurements of Radionuclides in the Environment, Sampling and Analysis of Plutonium in Soil," NRC Reg. Guide 4.5. All new procedures and changes to existing procedures must be thoroughly tested, documented, and approved in writing by the Manager of HS&EL before being implemented. Environmental Analysis is notified of any major changes that could affect analytical results. All procedures are reviewed annually for consistency with state-of-the-art techniques, or at any time an analytical problem is suspected.

Copies of all procedures are kept on file in the office of the Manager of HS&EL.

The following is a general outline of the analytical procedures followed by the laboratories:

Samples received for gross alpha and gross beta screening are counted approximately 24 and 48 hours after collection. Samples exceeding the limits set by Environmental Analysis are recounted 72 hours after collection.

Water samples scheduled for gamma spectral analysis are poured into one-liter Marinelli® containers and are sealed before delivery to the gamma counting area. Routine water samples are counted for approximately eight hours. Samples requiring a lower detection limit are counted from 16 to 72 hours.

Soil samples scheduled for gamma spectral analysis are dried, sieved through a ten-mesh sieve, weighed, and the fine portion is ball-milled. The fine portion is then placed in a 500-mℓ Marinelli container and counted for at least 16 hours.

Filter samples scheduled for gamma analysis are placed in petri dishes and counted for approximately 16 hours.

All samples scheduled for alpha spectral analysis are analyzed in a similar manner regardless of matrix. Prior to dissolution, a known quantity of nonindigenous radioactive tracer is added to each sample. The tracer is used to determine the chemical recovery for the analysis. Tracers used include Pu-236, Pu-242, U-232, U-236, Am-243, and Cm-244. The type and activity level of the tracer used depends on the type and projected activity level of the sample to be analyzed.

After samples are dissolved, radioisotopes of concern are separated from each other and from the matrix material by various solvent extraction and ion exchange techniques. The purified radioisotopes are electrodeposited onto stainless steel discs. These discs are alpha counted for a minimum of 16 hours. If a lower minimum detection limit is required, samples may be counted from 72 to 168 hours depending upon the need. Samples that exhibit a chemical recovery of less than 10 percent or greater than 110 percent are automatically scheduled for reanalysis.

Tritium analyses are routinely performed on specified environmental water samples as well as

5. The chemist in charge of the laboratory believes there is reason to suspect the analysis.

Any unusual condition affecting the results, which is noted either during sample collection or analysis, is reported to Environmental Analysis.

Table B-1 is a summary of HS&EL participation in the Rocky Flats Chemistry Standards Laboratory Bioassay and Environmental Measurements Program for 1983.

The HS&EL participate in the EPA Environmental Monitoring Systems Laboratory (EMSL) Crosscheck Program.

Table B-2 summarizes the HS&EL participation in this program.

TABLE B-1. Health, Safety and Environmental Laboratories Bioassay and Environmental Measurements Program Data (January Through December 1983)

Isotopes Reported	Matrix	Method	Standard Range	Normal Sample Range	Annual Relative[a] Error Percent	Total Control Analyses
Pu-239, -240	Water	Alpha Spectral	0-20 d/m/ℓ	0-5 d/m/ℓ	-12	60
Am-241	Water	Alpha Spectral	0-3 d/m/ℓ	0-3 d/m/ℓ	- 1	60
U-238, -234, -235	Water	Alpha Spectral	0-35 d/m/ℓ	0-30 d/m/ℓ	- 1	60
^{3}H	Water	Beta Liquid Scintillation	0-5000 pCi/ℓ	0-4500 pCi/ℓ	- 9	60
Pu-239, -240	Whatman Filters	Alpha Spectral	0-30 d/m/f	0-15 d/m/f	9	120
Am-241	Whatman Filters	Alpha Spectral	0-4 d/m/f	0-3 d/m/f	5	120
U-238, -234, -235	Whatman Filters	Alpha Spectral	0-30 d/m/f	0-15 d/m/f	13	120
Be[b]	Whatman Filters	Atomic Absorption	0-5 µg/f	0-2 µg/f	3	120
Pu-239, -240	Glass Fiber Filters	Alpha Spectral	0-50 d/m/f	0-40 d/m/f	- 2	48
Be	Whatman Filters	Atomic Absorption	0-60 µg/f	0-20 µg/f	- 5	240
Pu-239, -240	Urine	Alpha Spectral	0-10 d/m	0-5 d/m	- 2	144
Am-241	Urine	Alpha Spectral	0-2 d/m	0-1 d/m	2	144
U-238, -234, -235	Urine	Alpha Spectral	0-25 d/m	0-20 d/m	2	144
^{3}H	Urine	Beta Liquid Scintillation	0-2700 pCi/ℓ	0-2500 pCi/ℓ	- 5	48

a. The ratio of the deviations of the 12-month differences to standard value in percent; i.e., observed value minus standard value divided by standard value times 100, equals the ratio as expressed in percent. The relative error for control measurements is often called the coefficient of variation where the dispersion of data (in this case, the average differences between measured and standard values) is divided by the average standard value submitted. This term is inclusive of all random and systematic error in the standards, analytical chemistry, and measurement process for a given nuclide, matrix, and procedure.

b. Analyzed by 881 General Laboratory.

TABLE B-2. Health, Safety and Environmental Laboratories Participation in the EPA Environmental Monitoring Systems Laboratory Crosscheck Program During 1983

Isotope Reported	Matrix	Method	Number of Analyses Reported	Relative Percent Error
Pu-239	Water	Alpha Spectral	2	-1
Total U	Water	Alpha Spectral	2	-1
^{3}H	Water	Beta Liquid Scintillation	3	-1
Gross Alpha	Water	Gamma Spectral	3	-1
Cs-137	Filter	Gamma Spectral	2	2
Gross Alpha	Filter	Gamma Spectral	2	4
^{3}H	Urine	Beta Liquid Scintillation	3	3

APPENDIX B
QUALITY CONTROL

A Quality Program Plan has been developed by the Environmental Analysis (EA) Section to provide controls for assurance that

- Current operating procedures exist for all phases of EA operations and that these procedures are implemented as written.
- Appropriate approvals are obtained prior to program initiation or change.
- The equipment used in sample collection and data analysis is appropriate to the assigned function and is operating as required.
- Accurate documentation exists for all programs, procedures, and actions.
- All variances from procedures or equipment use and performance are documented and explained with an impact assessment.
- Appropriate guidelines and standards for environmental monitoring are identified, and documentation of compliance is provided on a routine basis to Rocky Flats management, DOE, and to State and Federal regulatory agencies.

The Quality Program Plan establishes control points and delineates responsibilities for specific categories of activities; provides an information base from which procedures can be developed, updated, and/or implemented; establishes a state of emergency preparedness in its contingency plans; and provides documented evidence of intent to comply with rules and regulations of Federal, State, and local regulatory agencies.

The plan includes quality assurance flow charts and quality matrices that illustrate activity networks and corresponding quality elements of each responsibility area. A complete listing of activities and responsibilities is also included in the Plan.

To ensure data reliability, the Health, Safety and Environmental Laboratories (HS&EL) Quality Control Program Plan outlines the quality control methods used in all phases of laboratory operations.

This quality control program includes the following elements:

- Development, evaluation, improvement, modification, and documentation of analytical procedures.
- Scheduled instrument calibration, control charting, and preventive maintenance.
- Participation in interlaboratory quality comparison programs.
- Intralaboratory quality control programs.

All sample batches scheduled for analysis by the HS&EL Central Receiving Laboratory contain an average of 10 percent control samples. The controls consist of analytical blanks prepared in-house and standards prepared by the Rocky Flats Chemistry Standards Laboratory.

An analysis or group of analyses may be rejected and the sample or samples scheduled for reanalysis for one or more of the following reasons:

1. The chemical recovery is less than 10 percent or greater than 110 percent.
2. The analytical blanks in the analysis batch are out of acceptable range.
3. The standards in the analysis batch are not within acceptable limits of error.
4. The alpha energy spectrum is not acceptable because of the following:

   a. extra and/or unidentified peaks.

   b. excess noise in background areas.

   c. poor resolution of peaks.

TABLE A-1. Applicable Standards for Radioactive and Nonradioactive Materials

Legend

μCi = microcuries	g = grams
m^3 = cubic meters	40 CFR 61 = Code of Federal Regulations National Emission Standards for Hazardous Air Pollutants (USEPA)
mℓ = milliliters	
mg/ℓ = milligrams per liter	
SU = standard units	DOE = Department of Energy
NA = not applicable	NPDES = National Pollutant Discharge Elimination System
	CDH = Colorado Department of Health

Parameters	Applicable Guides and Standards	Reference
Airborne Effluents		
Plutonium 239, 240	NA	NA
Uranium 233, 234, 238	NA	NA
Tritium	NA	NA
Beryllium	<10.0 g/day	40 CFR 61.32(a)
Ambient Air		
Plutonium 239, 240	$<20.0 \times 10^{-15}$ μ Ci/mℓ	DOE Order 5480.1, CDH
Waterborne Effluents (Radioactive)		
Plutonium 239, 240	$<1{,}667 \times 10^{-9}$ μCi/mℓ	DOE Order 5480.1, CDH
Uranium 233, 234, 238	200×10^{-9} μCi/mℓ	DOE Order 5480.1
Americium 241	$<1{,}330 \times 10^{-9}$ μCi/mℓ	DOE Order 5480.1, CDH
Tritium	$<1{,}000 \times 10^{-6}$ μCi/mℓ	DOE Order 5480.1, CDH

Parameter	Discharge Limitations[a] Monthly Average	Daily Maximum	Reference
Effluent Water Samples (Nonradioactive)			
pH	6.0–9.0 SU		NPDES Permit
Nitrate as N	10 mg/ℓ	20 mg/ℓ	NPDES Permit
Total Phosphorus	8 mg/ℓ	NA	NPDES Permit
Biochemical Oxygen Demand, 5-Day	10 mg/ℓ	25 mg/ℓ	NPDES Permit
Suspended Solids	30 mg/ℓ	45 mg/ℓ	NPDES Permit
Total Chromium	0.05 mg/ℓ	0.1 mg/ℓ	NPDES Permit
Residual Chlorine	NA	0.5 mg/ℓ	NPDES Permit
Oil and Grease	NA	Visual	NPDES Permit
Fecal Coliform Count	400 organisms/100 mℓ	(7 day)	NPDES Permit
Fecal Coliform Count	200 organisms/100 mℓ	(30 day)	NPDES Permit
Total Organic Carbon	22 mg/ℓ	30 mg/ℓ	NPDES Permit

a. These limitations are presented as indicators of the types of parameters and associated concentration limits required by the NPDES permit. Details of these requirements specific to each discharge location are given in the referenced document.[7] The daily and monthly limitations indicated cannot be correlated with the annual water quality data summarized in Table 10.

Environmental uranium concentrations can be measured by a variety of laboratory techniques. Nonradiological techniques yield concentration units of mass per unit volume such as $\mu g/m^3$ and $\mu g/\ell$. The uranium concentrations given in this report were derived by measuring radioactivity from alpha-emitting uranium isotopes and are expressed in terms of activity units per unit volume. Rocky Flats data include measurements of depleted uranium, fully enriched uranium, and natural uranium.

Conversion factors for specific types of uranium can be used to compare the data in this report to data from other facilities and agencies that are given in units of mass per unit volume; however, the resulting approximations will not have the same assurance of accuracy as that for the original measured values. Uranium in effluent air from Plant buildings is primarily depleted uranium. The conversion factor for this data is 2.6×10^6 g/Ci. Natural uranium is the predominant form found in water. The conversion factor for water data is 1.5×10^6 g/Ci.

The applicable EPA standard for beryllium (a nonradioactive material) in airborne effluents from Plant buildings is 10 grams per stationary source in a 24-hour time period.[12] For ambient air, the applicable DOE and CDH RCG's for soluble plutonium 239 and 240 in uncontrolled areas and for the general population are 2.2×10^{-3} Bq/m^3 (60×10^{-15} μCi/mℓ and 7.4×10^{-4} Bq/m^3 (20×10^{-15} μCi/mℓ), respectively.[2,4]

The DOE and CDH soluble americium 241 RCG in waterborne effluents for the general population is 49 Bq/ℓ ($1{,}330 \times 10^{-9}$ μCi/mℓ).[2,4] The comparable RCG for plutonium 239, 240 in water is 62 Bq/ℓ ($1{,}667 \times 10^{-9}$ μCi/mℓ).[2,4] The most restrictive RCG for uranium 233, 234, and 238 in water is 7.4 Bq/ℓ (200×10^{-9} μCi/mℓ), which is the RCG for soluble uranium 238.[2] In waterborne effluents available to the general public, the RCG for tritium is 3700 Bq/ℓ ($1{,}000{,}000 \times 10^{-9}$ μCi/mℓ).

In 1976, the Environmental Protection Agency promulgated regulations for radionuclides in drinking water.[9] These regulations were effective on June 24, 1977, along with primary drinking water regulations for microbiological, chemical, and physical contaminants. The intent of the Safe Drinking Water Act was to ensure that each state has primary responsibility for maintaining drinking water quality. To comply with these requirements, the Colorado State Board of Health modified existing State drinking water standards to include radionuclides.[8] Two of the community drinking water standards are of interest in this report. The State standard for gross-alpha particle activity (including radium 266 but excluding radon and uranium) in community water systems is a maximum of 5.6×10^{-1} Bq/ℓ (15 pCi/ℓ or 15×10^{-9} μCi/mℓ). Americium and plutonium, which are alpha-emitting radionuclides, are included in this limit. The limit for tritium in drinking water is 740 Bq/ℓ (20,000 pCi/ℓ or $20{,}000 \times 10^{-9}$ μCi/mℓ).

The Rocky Flats Plant NPDES permit, which the EPA reissued in 1981 to DOE, established sanitary effluent limitations on discharge from Pond B-3 (sewage effluent), limitations for nitrate and pH in the discharge from Holding Pond A-3 in the Walnut Creek drainage, limitations on discharge from the reverse osmosis pilot plant on Woman Creek, limitations on discharge from the reverse osmosis plant, and control of sediment release during discharges from Ponds A-4, B-5, and C-2.

In addition to evaluating compliance with all relevant guides, limits, and standards, the Environmental and Occupational Health Branch assists operating groups in adhering to the DOE policy that "... operations shall be conducted in a manner to assure that radiation exposure to individuals and population groups is limited to the lowest levels technically and economically practicable."[2]

Standards for radioactive and nonradioactive materials, which are applicable to the Rocky Flats Plant, are shown in Table A-1.

VI. APPENDIXES

APPENDIX A
APPLICABLE GUIDES AND STANDARDS

The Rocky Flats Plant Environmental Monitoring Program includes evaluating Plant compliance with all relevant guides, limits, and standards. Guide values for radionuclides in ambient air and waterborne effluents have been adopted by the Department of Energy and the Colorado Department of Health.[2,4] The guides are based on recommendations published by the International Commission on Radiological Protection (ICRP) and the National Council on Radiation Protection and Measurement (NCRP). Limits for nonradioactive pollutants in effluent water have been defined by an Environmental Protection Agency National Pollutant Discharge Elimination System (NPDES) discharge permit.[7] In 1976, the EPA also established standards for radionuclides in drinking water.[9] These drinking water standards have been adopted, in turn, by the State of Colorado.[8]

The Radioactivity Concentration Guides (RCG's) published by DOE and CDH include permissible concentrations of specific radionuclides and mixtures of radionuclides in air (RCG_a) and water (RCG_w) for individuals in the general population.[2,4] These guides are reduced by a factor of three when applied to a suitable sample of the general population. Numerical values of the guides for specific radionuclides are cited in some of the tables presented in this report. The guides additionally restrict the concentration of radionuclides in a mixture such that the sum of the ratios of each radionuclide concentration to the appropriate concentration guide shall not exceed a value of one. The guides further state that a radionuclide may be considered as not present in a mixture if (a) the ratio of the concentration of that radionuclide in the mixture to the concentration guide for that radionuclide does not exceed one-tenth and (b) the sum of such ratios for all radionuclides considered as not present in the mixture does not exceed one-fourth.

During 1983, average specific radionuclide concentrations in air and water were all less than one-tenth of the appropriate concentration guides for specific radionuclides. The sum of the ratios of those average concentrations to their respective RCG's was less than one-fourth for all air and water sampling locations. The measured concentrations in the tables have, therefore, been compared to the concentration guides for specific radionuclides rather than to the guide for mixtures.

The RCG's for each radionuclide are specified for soluble and insoluble material. For purposes of comparing concentrations to RCG's, the more restrictive of the two (soluble or insoluble) RCG's is used. In this report, the RCG's for americium, plutonium, uranium, and tritium are referenced. The more restrictive RCG's for americium, plutonium, uranium, and tritium are for soluble material. Throughout this report, where a radionuclide concentration is expressed as the cumulative measurement of more than one isotope, the stated RCG used for comparison represents the most restrictive RCG for that grouping of isotopes. Plutonium concentrations measured at Rocky Flats represent the alpha radioactivity from plutonium isotopes 239 and 240, which constitute over 97 percent of the alpha radioactivity in plutonium handled at the Plant.

Reported uranium concentrations are the cumulative alpha activity from uranium 233, 234, and 238. Components containing fully enriched uranium metal are handled at the Rocky Flats Plant. Depleted uranium metal is fabricated and also is handled as process waste material. Uranium 235 is the major isotope by weight (93 percent) in fully enriched uranium; however, uranium 234 accounts for approximately 97 percent of the alpha activity of fully enriched uranium. In depleted uranium, the combined alpha activity from uranium 234 and 238 account for approximately 99 percent of the total alpha activity. The uranium RCG's used in this report for air and water are those for uranium 233, 234, and uranium 238, which are the most restrictive.

TABLE 26. Seventy-Year Dose Commitment From One Year of Chronic Intake/Exposure

Source	Total Body (rem)	Liver (rem)	Bone (rem)	Lungs (rem)
Maximum Site Boundary Location	5×10^{-5}	2×10^{-4}	3×10^{-4}	9×10^{-5}
Community	3.3×10^{-6}	3.8×10^{-4}	9.5×10^{-4}	2.4×10^{-4}

TABLE 27. Natural Radiation Background Dose for the Denver Metropolitan Area[a]

Source	Total Body[b] (rem/yr)	Liver[b] (rem/yr)	Bone (rem/yr)	Lungs (rem/yr)
Cosmic Radiation	0.050	0.050	0.050	0.050
Cosmic Radionuclides	0.0007	0.0007	0.0008	0.0007
External Terrestrial	0.072	0.072	0.057	0.072
Inhaled Radionuclides	–	–	–	0.100
Radionuclides in the Body	0.027	0.027	0.060	0.024
Total for One Year	0.1497	0.1497	0.1678	0.2467

a. Values in this table are a summary of values derived from Reference 18.
b. Values for the total body and liver are considered to be the same as the values reported for gonads in Reference 18.

10^{-5} Sv (1×10^{-3} rem or 1 mrem). A level of "~1 mrem/yr" or less is specified as a *de minimis* (inconsequential) level of exposure in the DOE prescribed standard, *A Guide to Reducing Radiation Exposure to As Low As Reasonably Achievable (ALARA).*[21] The Guide further states:

> "Radiation-induced mutations and diseases have not been discovered in populations that are or have been exposed to doses of 100 mrem/yr or less. Hence, it is reasonable to suggest that no health effects will be discerned if a population is exposed to an additional 1 percent of the level; i.e., ~1 mrem/yr. An annual dose of 1 mrem should be regarded as a level which is clearly *de minimis*."

Based on the *de minimis* concept in the Guide and on the maximum community dose estimates, the dose commitment for all individuals to 80 kilometers is considered to be *de minimis*.

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Measurements Laboratory.[20] This source term is 1×10^{3} Bq/m^2 (3×10^{-8} Ci/m^2). The americium is assumed to be present at an alpha activity level of 20 percent that of the plutonium, which is the maximum quantity of americium that can be present in Rocky Flats plutonium from the decay of plutonium 241.[1] The americium source term, therefore, is conservatively estimated to be 2×10^{2} Bq/m^2 (6×10^{-9} Ci/m^2).

Source terms and corresponding dose commitments were evaluated for each of the surrounding communities to determine the maximum community exposure. Ground-plane irradiation and water ingestion pathways were insignificant for all of the communities. The only significant pathway for radiation exposure was inhalation of plutonium in air. The source term for inhalation used in the dose assessment was the maximum annual average plutonium concentration measured in community ambient air [1.4×10^{-6} Bq/m^3 (3.8×10^{-17} Ci/m^3)]. This concentration was the annual average concentration measured in the Superior ambient air sampler.

A summary of the source terms for the maximum site boundary and for community locations is tabulated in Table 25.

B. Maximum Site Boundary Dose

The maximum dose to an individual continuously present at the site boundary is based on the radionuclide concentrations shown in Table 25. From these concentrations and the dose conversion factors in Table 24, a 70-year dose commitment of 5×10^{-7} Sv (5×10^{-5} rem) is calculated for the total body. The corresponding bone dose is 3×10^{-6} Sv (3×10^{-4} rem). The DOE radiation protection standards for individuals in uncontrolled areas are 5×10^{-3} Sv (5×10^{-1} rem) annually for the total body and 1.5×10^{-2} Sv (1.5 rem) each year for mineral bone.[2] The maximum site boundary dose represents 0.01 percent of the standard for total body and 0.02 percent of the standard for mineral bone.

C. Maximum Community Dose

Based on radionuclide concentrations in surrounding communities (Table 25), the calculated 70-year dose commitments were 3.3×10^{-8} Sv (3.3×10^{-6} rem) to the total body and 9.5×10^{-6} Sv (9.5×10^{-4} rem) to the bone. These values represent less than 0.002 percent and 0.2 percent, respectively, of the 1.7×10^{-3} Sv (1.7×10^{-1} rem) annual total body standard, for a suitable sample of the exposed population, and 5×10^{-3} Sv (5×10^{-1} rem) standard for mineral bone.[2]

The maximum site boundary and community dose commitments are summarized in Table 26. These values may be compared to an average dose rate reported for the Denver area of 1.5×10^{-3} and 1.68×10^{-3} Sv/yr (1.5×10^{-1} and 1.68×10^{-1} rem/yr) to the total body and bone, respectively, from natural radiation. (See Table 27.)

D. Eighty-Kilometer Dose Estimates

The dose commitment for all individuals, to a distance of 80 kilometers (50 miles) is based on the calculated maximum community dose estimates shown in Table 25. Estimated dose commitments, for each of the specific organs, are all less than 1 X

TABLE 25. Radioactivity Concentrations Used for 1983 Dose Calculations

	Air (Ci/m^3)	Water (Ci/ℓ)			Surface Deposition (Ci/m^2)	
Location	Pu-239, -240	Pu-239, -240	Am-241	U-233, -234	Pu-239, -240	Am-241
Maximum Site Boundary	5×10^{-18}	1.4×10^{-14}	7×10^{-15}	2.2×10^{-12}	3×10^{-8}	6×10^{-9}
Community	3.8×10^{-17}	–	–	–	–	–

TABLE 24. Dose Conversion Factors Used in Dose Assessment Calculations[a]

Organ	Inhalation[b] (rem·cubic meter / curie)	Water Ingestion[c] (rem·liter / curie)			Ground Plane Irradiation (rem·square meter / curie)	
	Pu-239, -240	Pu-239, -240	Am-241	U-233, -234	Pu-239, -240	Am-241
Total Body	8.60×10^{10}	5.22×10^{6}	5.33×10^{7}	4.41×10^{4}	2.84×10^{2}	7.57×10^{3}
Liver	9.99×10^{12}	6.03×10^{8}	6.21×10^{9}	(d)	(d)	(d)
Bone	2.50×10^{13}	1.51×10^{9}	1.49×10^{10}	(d)	(d)	(d)
Lung	6.31×10^{12}	(d)	(d)	(d)	(d)	(d)

a. These factors are taken from the Rocky Flats Plant Final Environmental Impact Statement.[1]
b. For 0.3-μm AMAD (Activity Median Aerodynamic Diameter), inhalation rate of 2.66×10^{-4} m^3/s for chronic exposure.[18]
c. For intake rate of 1.65 liters (1.75 quarts) per day.[18]
d. Values for the conversion factor are taken to be equal to that for the total body.

A. Dose Assessment Source Terms

Plutonium and americium in the Rocky Flats environs are the combined result of fallout deposition from atmospheric nuclear weapons testing and past releases from the Plant. Uranium, a naturally occurring element, is indigenous to many parts of Colorado and also is used in Plant operations in various isotopic ratios. Tritium, a radionuclide formed by natural processes, also is associated with Plant operations and fallout.

Inhalation source terms for the 1983 dose assessment were based on plutonium 239 and 240 concentrations measured in ambient air samples. The presence of plutonium in the air, from atmospheric weapons testing in previous years, causes these concentrations to be an overestimate of the Rocky Flats contribution. The ingestion source terms were based on measured concentrations of plutonium, americium, uranium, and tritium in water. The ground plane source terms were based on measured values of plutonium in soil and an assumed ratio of americium to plutonium alpha activity (0.20) in the soil. This ratio is the maximum level of americium in-growth from Rocky Flats plutonium.[1]

The maximum site-boundary dose assessment assumes that an individual is continuously present at the Plant perimeter, which actually is uninhabited. The plutonium inhalation source term of less than 2×10^{-7} Bq/m^3 (5×10^{-18} Ci/m^3) was the maximum annual average concentration of plutonium 239 and 240, as measured for a single location in the perimeter ambient air sampling network.

The water supply for the individual at the site boundary was assumed to be Walnut Creek, which intermittently flows offsite and provides the liquid effluent source term at the site boundary. During 1983, the plutonium concentration in Walnut Creek averaged 5.2×10^{-4} Bq/ℓ (1.4×10^{-14} Ci/ℓ). The average americium concentration was 3×10^{-4} Bq/ℓ (7×10^{-15} Ci/ℓ). These concentrations were used as the water ingestion source term for the maximum site boundary dose assessment. The average concentration of uranium in Walnut Creek was 1.5×10^{-1} Bq/ℓ (4.0×10^{-12} Ci/ℓ) while the average concentration in incoming raw water was 6.7×10^{-2} Bq/ℓ (1.8×10^{-12} Ci/ℓ). The source term for uranium ingestion was the difference between these two values [8.1×10^{-2} Bq/ℓ (2.2×10^{-12} Ci/ℓ)]. The average tritium concentration in Walnut Creek was 7.4×10^{1} Bq/ℓ (2.0×10^{-10} Ci/ℓ), which is within the background range typically measured in regional waters. Tritium in the water was, therefore, omitted from the dose assessment.

The ground-plane irradiation source term is based on the maximum plutonium in soil deposition at the Plant perimeter, as reported by the Environmental

TABLE 22. Radioactivity Concentrations in Forb Samples From Plots A and B, and Controls

(Values are picocuries per gram of ash, blank-corrected.)

	Pu-239, -240		
	Number of Analyses	$\bar{X}$	SD
Plot A	10	0.415	0.292
Plot B	10	0.066	0.128
Control	3	0.014	0.012

TABLE 23. Environmental Thermoluminescent Dosimeter Measurements

Location Category	Number of Locations	Number of Measurements	Annual Measured Dose (mrem)[a]
Onsite	17	135	139 ± 1
Perimeter	16	126	127 ± 1
Community	12	91	145 ± 2

a. The error terms reported represent the 95 percent confidence interval for the standard error of the mean (1.96 $\sigma_{\bar{X}}$), calculated from the variance of the individual measured values.

than about 100 keV. The use of TLD's for assessing external penetrating radiation in the environment has been evaluated under field and laboratory conditions and has been found to be a sensitive and reliable tool for environmental measurement of gamma radiation exposure.[15]

The environmental dosimeters have been individually calibrated (five times each), against an onsite gamma calibration source. The average calibration factor for each dosimeter is applied to measurements taken with that dosimeter. An additional correction is applied to correct for day-to-day variations in reader calibration.

The 1983 environmental measurements using TLD's are summarized in Table 23. The average annual dose equivalents, as measured onsite, in the perimeter environs, and in communities, were 1.39, 1.27, and 1.45 mSv (139, 127, and 145 mrem), respectively. These values are indicative of background gamma radiation in the area.[10]

V. ASSESSMENT OF POTENTIAL PLANT CONTRIBUTION TO PUBLIC RADIATION DOSE

Potential public radiation dose commitments, which could have resulted from Plant operations, were calculated from average radionuclide concentrations measured at the DOE property boundaries and in surrounding communities. Inhalation, water ingestion, and ground-plane irradiation were found to be the principal pathways of exposure. Swimming and consumption of foodstuffs and fish are insignificant pathways. This latter finding is to be expected because of limited swimming and fishing in the area and because most locally consumed food is produced at considerable distances from the Plant.

Dose assessment for 1983 was conducted for several locations: the DOE property (site) boundary, nearby communities, and sites to a distance of 80 kilometers (50 miles). Dose conversion factors used for the calculations were generated by computer codes that are described in detailed reports.[16,17] These conversion factors are listed in Table 24. The inhalation rate of 2.66×10^{-4} m^3/s and the water ingestion rate of 1.65 ℓ (1.75 quarts) per day were derived from data for reference man,[18] and were included in the dose conversion factors. Each of these dose conversion factors is for a 70-year dose commitment from one year of chronic exposure.

In deriving the inhalation source terms, solubility Class W is used for radionuclides in the total body, liver, and bone. Solubility Class W is defined by the ICRP Task Force on Lung Dynamics as material with a maximum clearance half-time from the lungs ranging from a few days to a few months.[19] Solubility Class Y, used by the ICRP to describe materials retained in the lungs with a maximum biological half-time ranging from 6 months to several years, is used for the lungs.[19] Obviously, the inhaled material cannot be both Class W and Class Y simultaneously as this treatment suggests; however, since the exact solubility of the inhaled material is not known, this treatment is conservatively used to yield a maximum calculated dose to any of the referenced organs regardless of the actual solubility.

TABLE 21. Plutonium Concentrations in Rocky Flats Plant Soil Samples From One Eastern Boundary Location

Location[c]	Surface[a] (pCi/g)[d]	Core[b] (pCi/g)[d]
16-1	7.26 ± 0.53	0.84 ± 0.06
16-3	8.58 ± 0.58	1.52 ± 0.10
16-14	12.2 ± 0.9	1.72 ± 0.14
16-18	9.33 ± 0.73	1.37 ± 0.12
16-23	8.78 ± 0.63	1.11 ± 0.09
16-25	6.66 ± 0.46	0.86 ± 0.07
16-30	12.3 ± 0.9	2.83 ± 0.25
16-32	12.8 ± 1.1	1.06 ± 0.09
16-33	9.82 ± 0.63	1.72 ± 0.17
16-38	11.2 ± 0.8	1.83 ± 0.14
16-44	8.22 ± 0.55	1.21 ± 0.10
16-46	9.84 ± 0.75	0.83 ± 0.07
16-54	14.3 ± 0.9	1.21 ± 0.11
16-57	11.8 ± 1.0	1.44 ± 0.13
16-61	12.2 ± 0.8	1.00 ± 0.09
Mean	10.4 ± 0.8	1.37 ± 0.12
Median	9.84	1.21
RSD[e]	22%	38%

a. Sampled to a depth of 5 cm.
b. Sampled from 5 to 20 cm.
c. The first number of each location refers to site 16 as shown in Figure 12. The second number is the sample location on the grid at site 16.
d. Concentrations are for the less than 2 mm size fraction of soil.
e. Percent relative standard deviation of the mean.

During May 1983, all standing grass was clipped from 1.0-m^2 frames located randomly at 10 sites in each of two plots (Figure 12). Vegetation samples were also collected from Lafayette, Colorado, which is approximately 16 km (10 mi) northeast of the Plant; these samples were employed as controls. All vegetation samples were analyzed by the Health, Safety and Environmental Laboratories. A statistical summary of the data is presented in Table 22.

Application of one-sided t-tests to the plutonium 239, 240 data indicated that Plot A forb samples contained more of these radionuclides than control and Plot B samples. There was no statistically significant difference between vegetation from Plot B versus control. For comparison, two forb samples were collected from these same two plots in 1980. The 1980 plutonium 239, 240 average concentrations from Plots A and B were 0.47 and <0.04 pCi/g, respectively.

J. External Gamma Radiation Dose Monitoring

Thermoluminescent dosimeters (TLD's) are used to measure external penetrating gamma radiation exposure at 45 locations on and off the Plant site. Two TLD's are located at each site for an exposure period of 3 months. The TLD's are placed at 17 locations within the property enclosed by the security fence shown in Figure 3. Measurements are also made at 16 perimeter locations 3 to 6 kilometers (2 to 4 miles) from the Plant and in 12 communities located within 50 kilometers (30 miles) of the Plant. The TLD's are placed at a height of 1 meter (3 feet) above ground level.

Each TLD consists of a sealed glass bulb enclosing two extruded ribbons of CaF_2:Mn (TLD-400) that sandwich a central metal heater strip. The TLD's are encased in an energy-compensating shield to reduce over-response to photons with energies less

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17, and 25 were sampled in 1981, and sites 16, 5, and 9 were sampled in 1982. The EPA comparison study has been performed at sites 2, 5, 9, 13, 17, 21, 25, and 28. The plutonium migration study is under way at site 16.

Nine composite samples, composed of nine subsamples each, were collected at site 2, which is shown in Figure 12. Collection was done according to published procedures.[5, 14] Each set of nine subsamples was collected on a spacing of 20 meters (65.6 feet) and composited to yield one of the nine final samples. The geometry of each subsample was controlled by use of a 10 X 10 X 1 centimeter (4 X 4 X 0.4 inch) cutting tool. The soil contained within the tool cavity was removed and analyzed for plutonium.

Plutonium concentrations in soil samples from site 2 are shown in Table 20. The values are in the range from 2 to 8 Bq/kg (0.06 to 0.23 pCi/g). The relative standard deviation of 55 percent indicates that the plutonium deposition is not uniformly distributed in the soil at this site. The calculated areal distribution for plutonium at site 2 ranged from 0.1 X 10^8 to 0.6 X 10^8 Bq/km^2 (0.5 to 1.8 mCi/km^2). The median value at site 2 [0.3 X 10^8 Bq/km^2 (0.8 mCi/km^2)] is 0.4 percent of the EPA proposed screening level for transuranium elements in soil.[5] The regional background value is approximately 1.5 mCi/km^2.

The fourth series of samples for the migration study was taken at site 16. (See Figure 12.) Thirty samples, made up of five composites each, were taken at 15 locations. These locations were selected on a random basis from a grid of 64 squares [2 m (6.6 ft) on each side of a square] separated by alleys 1 meter wide. The subsamples were taken from the four corners and the center of each square.

The samples from each square consisted of surface and core samples. Surface material was taken by means of a 10 X 10 X 5-centimeter (4 X 4 X 2 inch) cutting tool, and soil from the interior of the tool was carefully removed for analysis. The core samples were taken from the same sites as the surface samples by means of an orchard auger measuring 8.3 centimeters (3.3 inches) in diameter.

TABLE 20. Plutonium Concentrations in Rocky Flats Plant Surface Soil Samples at One East Boundary Location

Location	pCi/g[a]	mCi/km^2 [b]
2-1	0.09 ± 0.01	0.8
2-2	0.09 ± 0.01	0.9
2-3	0.09 ± 0.01	0.7
2-4	0.08 ± 0.01	0.6
2-5	0.10 ± 0.01	0.9
2-6	0.23 ± 0.02	1.8
2-7	0.06 ± 0.01	0.5
2-8	0.11 ± 0.02	0.8
2-9	0.20 ± 0.02	1.4
Mean	0.11 ± 0.01	0.9
Median	0.09	0.8
RSD[c]	55%	–

a. Concentrations are for the fraction of soil measuring less than 2 mm in diameter.
b. Samples were collected to a depth of 1 cm.
c. Percent relative standard deviation of the mean.

The depth of the cores was from 5 to 20 centimeters (2 to 8 inches). Surface samples and core samples were retained as individual samples but received identical preparation and analysis.

Plutonium concentrations in surface soil and soil core samples at site 16 are shown in Table 21. The range of values for surface samples at site 16 was between 246 and 529 Bq/kg (6.66 and 14.3 pCi/g). These values are within the range of those determined in 1980, 1981, and 1982. Core samples contained plutonium in the range between 31 and 105 Bq/kg (0.83 and 2.83 pCi/g). The median value was 45 Bq/kg (1.21 pCi/g). These values are not significantly different from those measured in previous years.

H. Vegetation Sampling and Analysis

Vegetation from the Rocky Flats Plant is periodically sampled and analyzed for plutonium 239 and 240. This sampling is part of an ecological monitoring program designed to aid in evaluating the environmental impact of the Plant.

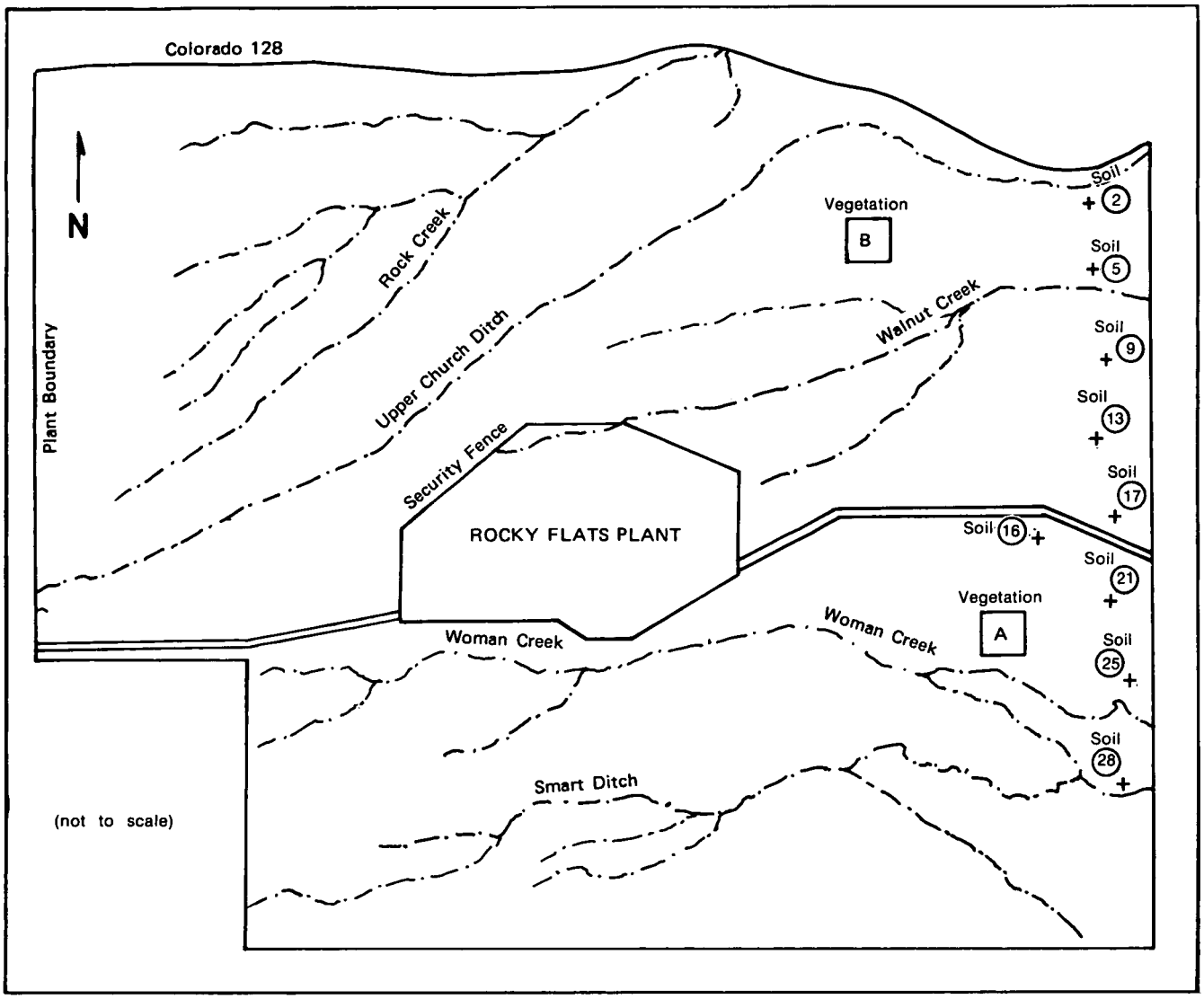

FIGURE 12. Location of Soil and Vegetation Sampling Plots

TABLE 19. Tritium Activity Concentrations in Public Water Supplies

Location	Number of Analyses	C_{min}	C_{max}	C_{avg}	Percent of RCG_w [a]
Reservoir		Tritium Concentration ($\times 10^{-9}$ μCi/mℓ)			
Boulder	1	300 ± 800	300 ± 800	300 ± 800	0.03
Dillion	1	300 ± 800	300 ± 800	300 ± 800	0.03
Great Western	51	-500 ± 400	500 ± 800	100 ± 100	0.01
Ralston	1	200 ± 800	200 ± 800	200 ± 800	0.02
South Boulder Diversion Canal	1	400 ± 800	400 ± 800	400 ± 800	0.04
Standley	51	-500 ± 600	700 ± 800	200 ± 100	0.02
Drinking Water					
Arvada	4	-100 ± 600	300 ± 400	100 ± 300	0.01
Boulder	51	-400 ± 500	800 ± 800	200 ± 100	0.02
Broomfield	51	-500 ± 400	700 ± 800	100 ± 100	0.01
Denver	4	200 ± 500	400 ± 700	300 ± 300	0.03
Golden	4	0 ± 500	300 ± 500	100 ± 300	0.01
Lafayette	4	-100 ± 500	400 ± 700	200 ± 300	0.02
Louisville	4	-100 ± 400	400 ± 500	100 ± 300	0.01
Thornton	4	200 ± 700	400 ± 500	300 ± 300	0.03
Westminster	51	-400 ± 500	800 ± 500	100 ± 100	0.01

a. The Radioactivity Concentration Guide (RCG_w) for tritium in water available to the general population is 1,000,000 $\times 10^{-9}$ μCi/mℓ. The EPA and State of Colorado Primary Drinking Water Regulation limits for tritium are 20,000 $\times 10^{-9}$ μCi/mℓ.

TABLE 18. Plutonium, Uranium, and Americium Activity Concentrations in Public Water Supplies

Location	Number of Analyses	C_{min}	C_{max}	C_{avg}	Percent of RCG_w
Reservoir		Plutonium Concentration ($\times 10^{-9}$ μCi/mℓ)[a]			
Boulder	1	0.001 ± 0.004	0.001 ± 0.004	0.001 ± 0.004	<0.001
Dillon	1	0.012 ± 0.006	0.012 ± 0.006	0.012 ± 0.006	<0.001
Great Western	12	-0.007 ± 0.007	0.02 ± 0.03	0.005 ± 0.004	<0.001
Ralston	1	0.004 ± 0.005	0.004 ± 0.005	0.004 ± 0.005	<0.001
South Boulder Diversion Canal	1	0.001 ± 0.002	0.001 ± 0.002	0.001 ± 0.002	<0.001
Standley	12	-0.016 ± 0.009	0.01 ± 0.01	-0.002 ± 0.002	<0.001
Drinking Water					
Arvada	4	-0.005 ± 0.004	0.001 ± 0.003	-0.002 ± 0.002	<0.001
Boulder	12	-0.02 ± 0.01	0.036 ± 0.008	0.002 ± 0.002	<0.001
Broomfield	12	-0.03 ± 0.01	0.02 ± 0.02	0.002 ± 0.003	<0.001
Denver	4	-0.006 ± 0.007	0.001 ± 0.004	-0.002 ± 0.003	<0.001
Golden	4	-0.001 ± 0.002	0.011 ± 0.009	0.003 ± 0.003	<0.001
Lafayette	4	-0.002 ± 0.004	0.002 ± 0.004	0.000 ± 0.002	<0.001
Louisville	4	-0.003 ± 0.005	0.002 ± 0.004	-0.001 ± 0.002	<0.001
Thornton	4	-0.01 ± 0.01	0.00 ± 0.02	-0.004 ± 0.006	<0.001
Westminster	12	-0.01 ± 0.02	0.04 ± 0.02	0.002 ± 0.004	<0.001
Reservoir		Uranium Concentration ($\times 10^{-9}$ μCi/mℓ)[b]			
Boulder	1	3.4 ± 0.3	3.4 ± 0.3	3.4 ± 0.3	1.7
Dillon	1	2.0 ± 0.2	2.0 ± 0.2	2.0 ± 0.2	1.0
Great Western	12	1.9 ± 0.1	3.3 ± 0.3	2.2 ± 0.1	1.1
Ralston	1	2.1 ± 0.2	2.1 ± 0.2	2.1 ± 0.2	1.0
South Boulder Diversion Canal	1	0.4 ± 0.1	0.4 ± 0.1	0.4 ± 0.1	0.2
Standley	12	0.86 ± 0.05	3.4 ± 0.3	1.7 ± 0.1	0.8
Drinking Water					
Arvada	4	0.37 ± 0.08	4.3 ± 0.4	1.6 ± 0.1	0.8
Boulder	12	-0.05 ± 0.09	0.6 ± 0.2	0.14 ± 0.02	0.07
Broomfield	12	1.3 ± 0.2	3.0 ± 0.4	2.2 ± 0.1	1.1
Denver	4	0.6 ± 0.1	1.8 ± 0.3	1.2 ± 0.1	0.6
Golden	4	0.5 ± 0.1	1.8 ± 0.2	1.2 ± 0.1	0.6
Lafayette	4	0.10 ± 0.04	1.4 ± 0.2	0.6 ± 0.1	0.3
Louisville	4	0.02 ± 0.03	0.2 ± 0.1	0.12 ± 0.03	0.06
Thornton	4	0.6 ± 0.1	1.5 ± 0.2	1.1 ± 0.1	0.6
Westminster	12	0.36 ± 0.08	1.2 ± 0.2	0.79 ± 0.04	0.4
Reservoir		Americium Concentration ($\times 10^{-9}$ μCi/mℓ)[c]			
Boulder	1	-0.02 ± 0.01	-0.02 ± 0.01	-0.02 ± 0.01	<0.001
Dillon	1	-0.006 ± 0.007	-0.006 ± 0.007	-0.006 ± 0.007	<0.001
Great Western	12	-0.01 ± 0.01	0.02 ± 0.03	0.003 ± 0.005	<0.001
Ralston	1	-0.003 ± 0.006	-0.003 ± 0.006	-0.003 ± 0.006	<0.001
South Boulder Diversion Canal	1	-0.002 ± 0.005	-0.002 ± 0.005	-0.002 ± 0.005	<0.001
Standley	12	-0.03 ± 0.04	0.04 ± 0.04	-0.004 ± 0.005	<0.001
Drinking Water					
Arvada	4	-0.017 ± 0.008	0.005 ± 0.009	-0.004 ± 0.004	<0.001
Boulder	12	-0.02 ± 0.02	0.04 ± 0.03	0.002 ± 0.006	<0.001
Broomfield	12	-0.03 ± 0.05	0.01 ± 0.03	-0.004 ± 0.006	<0.001
Denver	4	-0.02 ± 0.02	0.01 ± 0.02	-0.004 ± 0.009	<0.001
Golden	4	-0.01 ± 0.01	0.00 ± 0.01	-0.004 ± 0.004	<0.001
Lafayette	4	0.005 ± 0.008	0.01 ± 0.01	0.002 ± 0.004	<0.001
Louisville	4	-0.01 ± 0.01	0.01 ± 0.01	-0.002 ± 0.005	<0.001
Thornton	4	-0.01 ± 0.06	0.00 ± 0.01	0.00 ± 0.02	<0.001
Westminster	12	-0.02 ± 0.06	0.00 ± 0.02	0.005 ± 0.006	<0.001

a. Radiochemically determined as plutonium 239 and 240. The Radioactivity Concentration Guide (RCG_w) for soluble plutonium in water available to the general population is 1667×10^{-9} μCi/mℓ.

b. Radiochemically determined as uranium 233, 234, and 238. The most restrictive RCG_w for these uranium isotopes in the soluble form in water available to the general population is 200×10^{-9} μCi/mℓ.

c. Radiochemically determined as americium 241. The RCG_w for soluble americium 241 in water available to the general population is 1330×10^{-9} μCi/mℓ.

F. Regional Water Monitoring

Regional water monitoring includes sampling and analysis of public water supplies and tap water from several surrounding communities. Of the regional water supplies, only Great Western Reservoir and Standley Lake receive runoff from Rocky Flats drainage systems (Figure 4). The Rocky Flats contributions to radionuclides in regional water supplies through airborne emissions were estimated in the Rocky Flats Plant Site Final Environmental Impact Statement.[1] These contributions were insignificant compared to contributions from fallout and natural background.

Water samples were collected weekly from Great Western Reservoir, a water supply for the city of Broomfield, and from Standley Lake, a water supply for the city of Westminster and portions of the cities of Thornton and Northglenn. The weekly samples were composited into a monthly sample, and analyses were performed for plutonium, uranium, and americium concentrations. Tritium analysis was conducted for each weekly sample. Annual grab samples were also collected from three additional regional reservoirs (Ralston, Dillon, and Boulder) and one stream (South Boulder Diversion Canal) at distances ranging from 1.6 to 96 km (1 to 60 mi) from the Plant. These samples were collected to determine background data in water for plutonium, uranium, americium, and tritium. These data are presented in Tables 18 and 19.

Drinking water from Boulder, Broomfield, and Westminster was collected weekly, composited monthly, and analyzed specifically for plutonium, uranium, and americium. Tritium analyses were performed on weekly grab samples. Quarterly grab samples of tap water were collected from the surrounding communities of Arvada, Denver, Golden, Lafayette, Louisville, and Thornton. Samples were analyzed specifically for plutonium, uranium, americium, and tritium. Results also are presented in Tables 18 and 19.

Evaluation of the regional reservoir and drinking water data indicates no unusual results. The plutonium, uranium, americium, and tritium concentration data for the regional reservoirs represented a small fraction (1.7 percent or less) of the applicable RCG_W[2,4]. In the case of Great Western Reservoir, the average plutonium concentration was 1.8×10^{-4} Bq/ℓ (0.005×10^{-9} μCi/mℓ). This value is in the range of concentrations anticipated for Great Western Reservoir in the Rocky Flats Plant Final Environmental Impact Statement.[1] The values given in the Impact Statement are based on known plutonium in the reservoir sediments. Results of the plutonium, uranium, americium, and tritium data for 1983 drinking water in nine communities were all in the range of background. All drinking water values were 1.1 percent or less of the applicable RCG_W.[2,4]

Drinking water standards have been adopted by the State of Colorado[8] and the EPA[9] for alpha-emitting radionuclides (excluding uranium and radon) and for tritium. These standards are 5.55×10^{-1} Bq/ℓ and 740 Bq/ℓ (15×10^{-9} μCi/mℓ and $20{,}000 \times 10^{-9}$ μCi/mℓ) respectively. During 1983, the sum of the average concentrations of plutonium and americium (alpha-emitting radionuclides) in each community tap water sample was 2.5×10^{-4} Bq/ℓ (0.007×10^{-9} μCi/mℓ) or less. That value is 0.05 percent or less of the alpha activity standard. The tritium concentrations in Great Western Reservoir, Standley Lake, and in all community tap water samples averaged less than 14.8 Bq/ℓ (400×10^{-9} μCi/mℓ). That value is typical of background tritium concentrations in Colorado and represents 1.6 percent or less of the State of Colorado and EPA Drinking Water Standard for tritium.[8,9]

G. Soil Sampling and Analysis

Soil samples were collected during 1983 as part of a long-range monitoring program that was initiated in 1979. The program is designed to provide information on possible migration of plutonium in soil and to provide data for comparison with the EPA proposed guidance on transuranium elements in the environment.[5]

Samples were taken at two locations west of Indiana Street within the eastern boundaries of the Plant. The sites are shown in Figure 12 as numbers 2 and 16. Sites 13 and 21 were sampled in 1979, sites 16 and 28 were sampled in 1980, sites 16,

TABLE 17. Tritium Activity Concentrations in Groundwater Monitoring Wells

Location Number	Depth (meters)	Tritium Concentration ($\times 10^{-9}$ µCi/mℓ) February	June	August	November
1-60	6	600 ± 500	800 ± 500	300 ± 700	100 ± 400
2-60	7	900 ± 500	1100 ± 500	1200 ± 700	900 ± 700
3-60	9	300 ± 500	300 ± 500	600 ± 800	100 ± 400
4-60	9	1800 ± 500	3100 ± 600	2700 ± 900	2000 ± 500
5-60	9	Dry	500 ± 500	700 ± 800	Dry
6-60	9	500 ± 500	100 ± 500	300 ± 700	300 ± 400
1-66	45	100 ± 500	0 ± 500	500 ± 800	-100 ± 400
2-66	43	800 ± 500	1100 ± 500	1200 ± 700	800 ± 400
3-66	47	700 ± 500	1200 ± 500	1200 ± 800	800 ± 400
1-68	1	Dry	Dry	Dry	Dry
2-68	1	Dry	Dry	Dry	Dry
3-68	1	Dry	Dry	Dry	Dry
4-68	1	Dry	Dry	Dry	Dry
1-71	9	300 ± 500	400 ± 500	0 ± 700	200 ± 400
2-71	9	100 ± 400	100 ± 500	300 ± 800	100 ± 400
3-71	8	400 ± 500	200 ± 500	700 ± 800	200 ± 400
4-71	7	100 ± 500	-300 ± 500	300 ± 800	-300 ± 400
5-71	9	Dry	200 ± 500	800 ± 800	Dry
6-71	9	1600 ± 500	1200 ± 500	1700 ± 800	1100 ± 500
1-74	7	0 ± 400	400 ± 500	300 ± 800	400 ± 400
3-74	7	300 ± 400	500 ± 500	300 ± 700	0 ± 400
4-74	2	Dry	300 ± 500	Dry	Dry
5-74	5	Dry	-100 ± 500	Dry	Dry
6-74	2	Dry	Dry	Dry	Dry
7-74	15	100 ± 400	-100 ± 500	700 ± 800	200 ± 600
8-74	12	300 ± 500	300 ± 500	600 ± 800	Dry
9-74	6	0 ± 500	200 ± 500	400 ± 800	200 ± 400
10-74	3	Dry	0 ± 500	200 ± 800	-100 ± 400
13-74	6	400 ± 500	300 ± 500	700 ± 800	500 ± 400
14-74	1	Dry	-100 ± 500	Dry	Dry
15-74	6	300 ± 500	200 ± 500	0 ± 700	300 ± 400
16-74	1	Dry	Dry	Dry	Dry
17-74	5	400 ± 400	600 ± 500	700 ± 800	300 ± 600
18-74	2	0 ± 500	Dry	Dry	500 ± 400
21-74	81	-300 ± 500	400 ± 500	500 ± 700	400 ± 400
22-74	96	400 ± 500	-100 ± 500	400 ± 700	0 ± 400
WS-1	4	400 ± 500	-700 ± 500	200 ± 700	Dry
WS-2	3	Dry	100 ± 500	Dry	-100 ± 600
WS-3	4	400 ± 500	-600 ± 500	Dry	Dry
1-81	6	100 ± 500	-500 ± 500	-100 ± 700	0 ± 400
2-81	6	300 ± 400	-500 ± 500	900 ± 800	200 ± 400
3-81	6	-200 ± 400	300 ± 500	0 ± 700	0 ± 600
4-81	1	Dry	Dry	Dry	Dry
5-81	6	500 ± 500	-400 ± 500	700 ± 800	100 ± 400
6-81	9	0 ± 400	-300 ± 500	500 ± 700	100 ± 400
7-81	9	-300 ± 400	-100 ± 500	Dry	100 ± 400
8-81	30	200 ± 500	0 ± 500	600 ± 800	-200 ± 400
9-81	9	300 ± 500	200 ± 500	800 ± 800	200 ± 400
10-81	9	200 ± 500	200 ± 500	600 ± 800	300 ± 400
1-82	6	-200 ± 400	0 ± 500	300 ± 700	-200 ± 400
2-82	3	Dry	100 ± 500	300 ± 700	Dry
3-82	9	300 ± 500	200 ± 500	500 ± 500	400 ± 400
4-82	9	Dry	Dry	Dry	Dry
5-82	9	200 ± 500	-400 ± 500	500 ± 700	100 ± 400
6-82	9	100 ± 500	700 ± 500	200 ± 700	200 ± 400
7-82	9	0 ± 400	-500 ± 500	0 ± 400	300 ± 400

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TABLE 16. Americium Activity Concentrations in Groundwater Monitoring Wells

Location Number	Depth (meters)	Americium Concentration[a] ($\times 10^{-9}$ µCi/mℓ) February	June	August	November
1-60	6	-0.03 ± 0.05	-0.01 ± 0.09	-0.01 ± 0.05	0.00 ± 0.04
2-60	7	-0.03 ± 0.04	-0.02 ± 0.04	-0.04 ± 0.06	-0.01 ± 0.05
3-60	9	-0.01 ± 0.05	-0.01 ± 0.04	0.01 ± 0.08	-0.02 ± 0.04
4-60	9	0.00 ± 0.05	-0.02 ± 0.03	-0.02 ± 0.04	0.03 ± 0.05
5-60	9	Dry	-0.03 ± 0.04	0.05 ± 0.07	Dry
6-60	9	0.01 ± 0.05	-0.04 ± 0.03	-0.03 ± 0.06	-0.03 ± 0.05
1-66	45	0.00 ± 0.04	-0.03 ± 0.04	0.00 ± 0.05	-0.03 ± 0.03
2-66	43	-0.01 ± 0.04	-0.03 ± 0.04	0.00 ± 0.03	-0.03 ± 0.04
3-66	47	0.02 ± 0.05	-0.03 ± 0.04	-0.05 ± 0.06	0.08 ± 0.07
1-68	1	Dry	Dry	Dry	Dry
2-68	1	Dry	Dry	Dry	Dry
3-68	1	Dry	Dry	Dry	Dry
4-68	1	Dry	Dry	Dry	Dry
1-71	9	0.06 ± 0.06	0.00 ± 0.03	0.02 ± 0.05	-0.01 ± 0.03
2-71	9	0.03 ± 0.02	0.00 ± 0.08	-0.03 ± 0.07	0.00 ± 0.03
3-71	8	0.01 ± 0.05	0.01 ± 0.06	0.03 ± 0.05	-0.02 ± 0.03
4-71	7	0.04 ± 0.05	0.00 ± 0.05	-0.01 ± 0.08	-0.02 ± 0.03
5-71	9	Dry	0.00 ± 0.04	0.00 ± 0.03	Dry
6-71	9	-0.03 ± 0.05	-0.02 ± 0.05	0.02 ± 0.04	-0.03 ± 0.07
1-74	7	0.01 ± 0.07	-0.02 ± 0.05	-0.03 ± 0.02	0.00 ± 0.04
3-74	7	0.00 ± 0.06	-0.02 ± 0.05	0.00 ± 0.05	-0.03 ± 0.03
4-74	2	Dry	Dry	Dry	Dry
5-74	5	Dry	-0.01 ± 0.04	Dry	Dry
6-74	2	Dry	Dry	Dry	Dry
7-74	15	0.00 ± 0.04	0.01 ± 0.04	0.00 ± 0.05	-0.01 ± 0.04
8-74	12	-0.02 ± 0.04	0.00 ± 0.05	-0.01 ± 0.07	Dry
9-74	6	0.02 ± 0.07	-0.02 ± 0.05	-0.01 ± 0.03	-0.01 ± 0.03
10-74	3	Dry	0.01 ± 0.05	0.09 ± 0.09	0.00 ± 0.03
13-74	6	0.00 ± 0.05	-0.01 ± 0.03	0.01 ± 0.07	0.01 ± 0.04
14-74	1	Dry	-0.02 ± 0.05	Dry	Dry
15-74	6	0.03 ± 0.06	-0.01 ± 0.03	-0.01 ± 0.05	0.02 ± 0.04
16-74	1	Dry	Dry	Dry	Dry
17-74	5	0.00 ± 0.05	-0.01 ± 0.03	0.01 ± 0.02	0.01 ± 0.05
18-74	2	-0.01 ± 0.04	Dry	Dry	-0.01 ± 0.03
21-74	81	-0.03 ± 0.05	0.02 ± 0.05	0.00 ± 0.04	-0.02 ± 0.05
22-74	96	0.00 ± 0.04	-0.02 ± 0.06	0.05 ± 0.07	-0.30 ± 0.20
WS-1	4	0.02 ± 0.05	0.01 ± 0.04	-0.03 ± 0.08	Dry
WS-2	3	Dry	0.01 ± 0.05	Dry	0.02 ± 0.03
WS-3	4	0.00 ± 0.05	0.00 ± 0.04	Dry	Dry
1-81	6	-0.01 ± 0.05	0.00 ± 0.05	-0.06 ± 0.05	0.00 ± 0.01
2-81	6	0.00 ± 0.05	0.01 ± 0.04	-0.02 ± 0.03	0.00 ± 0.04
3-81	6	-0.03 ± 0.04	0.01 ± 0.06	-0.01 ± 0.09	-0.75 ± 0.51
4-81	1	Dry	Dry	Dry	Dry
5-81	6	-0.01 ± 0.06	0.04 ± 0.06	-0.03 ± 0.08	-0.02 ± 0.02
6-81	9	0.00 ± 0.06	0.00 ± 0.04	-0.01 ± 0.09	-0.02 ± 0.02
7-81	9	-0.02 ± 0.04	0.04 ± 0.05	Dry	-0.02 ± 0.03
8-81	30	0.00 ± 0.05	-0.05 ± 0.04	0.01 ± 0.04	-0.05 ± 0.04
9-81	9	0.02 ± 0.06	-0.02 ± 0.04	-0.05 ± 0.05	0.00 ± 0.03
10-81	9	-0.04 ± 0.05	-0.02 ± 0.03	-0.02 ± 0.12	-0.00 ± 0.08
1-82	6	0.01 ± 0.05	-0.02 ± 0.05	0.02 ± 0.04	-0.02 ± 0.03
2-82	3	Dry	-0.01 ± 0.06	0.02 ± 0.05	Dry
3-82	9	-0.01 ± 0.05	0.00 ± 0.05	-0.02 ± 0.08	-0.42 ± 0.30
4-82	9	Dry	Dry	Dry	Dry
5-82	9	0.03 ± 0.06	-0.01 ± 0.05	-0.07 ± 0.09	-0.02 ± 0.02
6-82	9	-0.01 ± 0.04	-0.01 ± 0.03	-0.08 ± 0.05	0.00 ± 0.04
7-82	9	-0.03 ± 0.05	-0.01 ± 0.02	-0.02 ± 0.09	-0.39 ± 0.30

a. Radiochemically determined as americium 241.

TABLE 15. Uranium Activity Concentrations in Groundwater Monitoring Wells

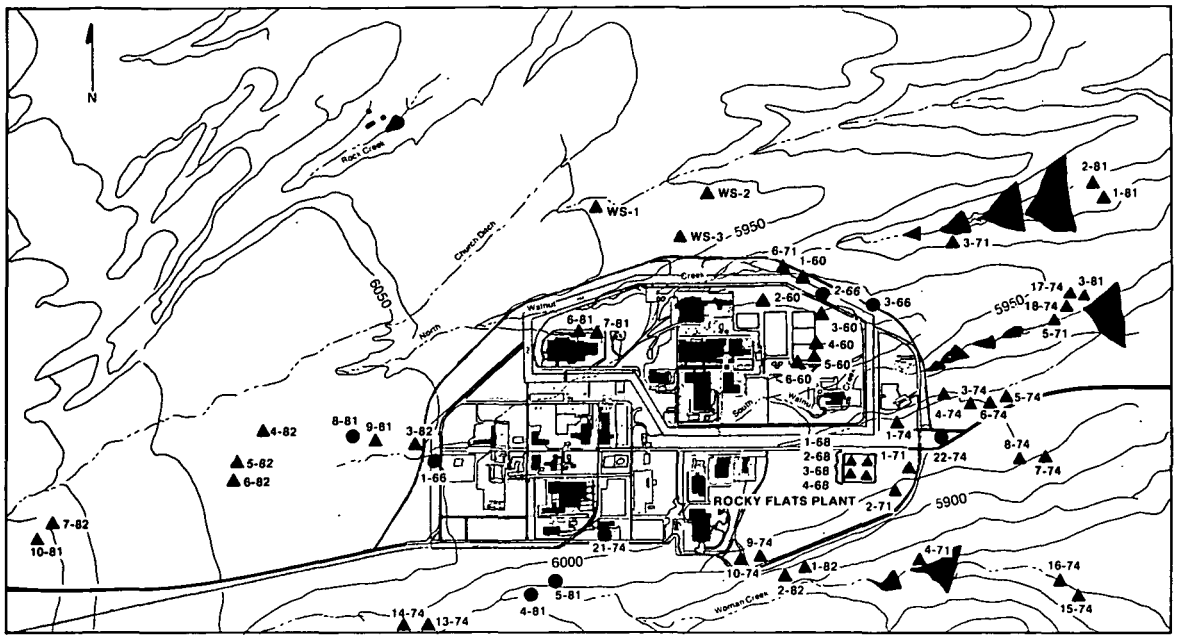
Location Number	Depth (meters)	Uranium Concentration[a] ($\times 10^{-9}$ μCi/mℓ) February	June	August	November
1-60	6	21 ± 3	15 ± 2	24 ± 2	21 ± 2
2-60	7	9 ± 2	25 ± 2	27 ± 2	12 ± 1
3-60	9	0.1 ± 0.1	4.9 ± 0.4	2.8 ± 0.3	9.5 ± 0.9
4-60	9	28 ± 2	34 ± 3	16.4 ± 0.7	12.1 ± 0.8
5-60	9	Dry	2.0 ± 0.1	2.9 ± 0.3	Dry
6-60	9	4.6 ± 0.7	0.8 ± 0.1	0.8 ± 0.1	3.0 ± 0.4
1-66	45	0.3 ± 0.2	0.4 ± 0.1	0.6 ± 0.1	0.12 ± 0.08
2-66	43	0.7 ± 0.1	1.1 ± 0.2	0.04 ± 0.06	0.6 ± 0.2
3-66	47	1.3 ± 0.3	0.83 ± 0.09	0.9 ± 0.2	1.7 ± 0.4
1-68	1	Dry	Dry	Dry	Dry
2-68	1	Dry	Dry	Dry	Dry
3-68	1	Dry	Dry	Dry	Dry
4-68	1	Dry	Dry	Dry	Dry
1-71	9	1.1 ± 0.4	0.8 ± 0.2	1.9 ± 0.3	3.3 ± 0.5
2-71	9	0.2 ± 0.2	0.05 ± 0.04	0.17 ± 0.08	0.13 ± 0.07
3-71	8	0.2 ± 0.2	0.3 ± 0.1	1.2 ± 0.2	0.9 ± 0.2
4-71	7	0.4 ± 0.2	0.6 ± 0.1	0.4 ± 0.1	0.8 ± 0.2
5-71	9	Dry	2.3 ± 0.3	0.9 ± 0.2	Dry
6-71	9	23 ± 1	19 ± 1	23 ± 2	3.3 ± 0.4
1-74	7	3.2 ± 0.4	2.3 ± 0.3	2.1 ± 0.2	3.8 ± 0.6
3-74	7	2.7 ± 0.3	1.7 ± 0.2	4.2 ± 0.4	3.3 ± 0.5
4-74	2	Dry	Dry	Dry	Dry
5-74	5	Dry	0.7 ± 0.1	Dry	Dry
6-74	2	Dry	Dry	Dry	Dry
7-74	15	3.3 ± 0.6	1.4 ± 0.2	3.8 ± 0.3	3.2 ± 0.5
8-74	12	2.6 ± 0.3	3.7 ± 0.5	1.7 ± 0.2	Dry
9-74	6	20 ± 2	6.9 ± 0.5	6.7 ± 0.5	10.5 ± 0.7
10-74	3	Dry	19 ± 1	20 ± 1	17.8 ± 0.6
13-74	6	6.1 ± 0.6	4.7 ± 0.4	5.2 ± 0.4	1.3 ± 0.3
14-74	1	Dry	1.1 ± 0.2	Dry	Dry
15-74	6	21 ± 2	21 ± 1	15.5 ± 0.8	23 ± 2
16-74	1	Dry	Dry	Dry	Dry
17-74	5	14 ± 1	17 ± 2	24 ± 2	28 ± 4
18-74	2	26 ± 2	Dry	Dry	23 ± 1
21-74	81	0.7 ± 0.1	0.4 ± 0.1	0.6 ± 0.1	0.2 ± 0.1
22-74	96	4.8 ± 0.5	5.4 ± 0.6	4.8 ± 0.4	5.3 ± 0.6
WS-1	4	0.3 ± 0.1	0.11 ± 0.09	0.04 ± 0.06	Dry
WS-2	3	Dry	2.3 ± 0.3	Dry	6.9 ± 0.6
WS-3	4	1.7 ± 0.3	2.3 ± 0.3	Dry	Dry
1-81	6	1.8 ± 0.3	3.7 ± 0.2	7.1 ± 0.8	3.9 ± 0.4
2-81	6	1.2 ± 0.2	1.9 ± 0.2	6.1 ± 0.5	3.7 ± 0.5
3-81	6	4.6 ± 0.4	16 ± 1	13 ± 1	1.9 ± 0.3
4-81	1	Dry	Dry	Dry	Dry
5-81	6	8.9 ± 0.9	8.0 ± 0.6	8.5 ± 0.7	9.3 ± 0.9
6-81	9	1.7 ± 0.4	0.7 ± 0.2	0.4 ± 0.1	2.6 ± 0.3
7-81	9	5.2 ± 0.6	3.0 ± 0.4	Dry	2.4 ± 0.3
8-81	30	0.9 ± 0.2	0.6 ± 0.2	1.0 ± 0.1	1.7 ± 0.3
9-81	9	0.2 ± 0.7	0.15 ± 0.08	0.02 ± 0.06	0.11 ± 0.07
10-81	9	0.9 ± 0.2	0.7 ± 0.1	0.06 ± 0.05	0.5 ± 0.2
1-82	6	21 ± 2	3.4 ± 0.4	17 ± 2	20 ± 1
2-82	3	Dry	3.4 ± 0.4	5.2 ± 0.5	Dry
3-82	9	0.3 ± 0.1	0.09 ± 0.09	0.05 ± 0.07	0.3 ± 0.1
4-82	9	Dry	Dry	Dry	Dry
5-82	9	0.0 ± 0.1	0.15 ± 0.05	0.02 ± 0.06	0.2 ± 0.1
6-82	9	0.3 ± 0.2	1.2 ± 0.1	0.2 ± 0.1	0.25 ± 0.09
7-82	9	0.9 ± 0.2	1.1 ± 0.2	0.9 ± 0.1	1.3 ± 0.4

a. Radiochemically determined as uranium 233, 234, and 238.

TABLE 14. Plutonium Activity Concentrations in Groundwater Monitoring Wells

Location Number	Depth (meters)	Plutonium Concentration[a] ($\times 10^{-9}$ μCi/mℓ) February	June	August	November
1-60	6	-0.04 ± 0.03	0.01 ± 0.03	-0.02 ± 0.07	-0.01 ± 0.02
2-60	7	-0.06 ± 0.03	-0.01 ± 0.04	-0.00 ± 0.02	-0.01 ± 0.03
3-60	9	-0.03 ± 0.04	0.02 ± 0.02	0.00 ± 0.02	-0.02 ± 0.01
4-60	9	-0.03 ± 0.03	0.00 ± 0.02	-0.01 ± 0.02	0.00 ± 0.02
5-60	9	Dry	0.02 ± 0.02	0.01 ± 0.02	Dry
6-60	9	-0.01 ± 0.02	0.00 ± 0.02	-0.00 ± 0.02	-0.02 ± 0.01
1-66	45	-0.04 ± 0.03	-0.01 ± 0.02	0.01 ± 0.02	-0.02 ± 0.01
2-66	43	-0.04 ± 0.03	0.00 ± 0.02	0.00 ± 0.01	0.00 ± 0.02
3-66	47	-0.03 ± 0.03	-0.01 ± 0.01	-0.01 ± 0.01	-0.01 ± 0.01
1-68	1	Dry	Dry	Dry	Dry
2-68	1	Dry	Dry	Dry	Dry
3-68	1	Dry	Dry	Dry	Dry
4-68	1	Dry	Dry	Dry	Dry
1-71	9	0.02 ± 0.04	-0.02 ± 0.03	0.01 ± 0.02	-0.03 ± 0.02
2-71	9	0.04 ± 0.03	0.01 ± 0.04	-0.02 ± 0.04	-0.01 ± 0.02
3-71	8	0.04 ± 0.03	0.01 ± 0.02	-0.01 ± 0.02	-0.02 ± 0.01
4-71	7	0.03 ± 0.03	-0.01 ± 0.02	0.00 ± 0.01	0.00 ± 0.02
5-71	9	Dry	0.00 ± 0.01	0.01 ± 0.02	Dry
6-71	9	0.01 ± 0.03	0.00 ± 0.02	0.01 ± 0.02	-0.01 ± 0.01
1-74	7	0.06 ± 0.05	0.01 ± 0.02	0.01 ± 0.02	-0.01 ± 0.01
3-74	7	-0.07 ± 0.03	0.01 ± 0.02	-0.02 ± 0.01	-0.01 ± 0.02
4-74	2	Dry	Dry	Dry	Dry
5-74	5	Dry	0.00 ± 0.02	Dry	Dry
6-74	2	Dry	Dry	Dry	Dry
7-74	15	-0.05 ± 0.03	0.00 ± 0.01	0.02 ± 0.02	0.00 ± 0.02
8-74	12	-0.04 ± 0.04	0.00 ± 0.02	0.02 ± 0.03	Dry
9-74	6	-0.01 ± 0.02	0.02 ± 0.03	0.02 ± 0.02	-0.02 ± 0.01
10-74	3	Dry	0.04 ± 0.03	0.02 ± 0.02	-0.01 ± 0.02
13-74	6	-0.03 ± 0.03	0.00 ± 0.02	-0.02 ± 0.02	0.02 ± 0.03
14-74	1	Dry	0.00 ± 0.02	Dry	Dry
15-74	6	-0.10 ± 0.03	0.01 ± 0.02	0.01 ± 0.02	-0.02 ± 0.01
16-74	1	Dry	Dry	Dry	Dry
17-74	5	-0.04 ± 0.03	-0.01 ± 0.02	0.01 ± 0.02	0.00 ± 0.02
18-74	2	-0.03 ± 0.03	Dry	Dry	-0.02 ± 0.02
21-74	81	-0.04 ± 0.03	0.02 ± 0.02	0.00 ± 0.01	0.00 ± 0.02
22-74	96	-0.03 ± 0.03	0.01 ± 0.02	0.00 ± 0.02	0.01 ± 0.02
WS-1	4	-0.04 ± 0.03	0.01 ± 0.02	0.00 ± 0.02	Dry
WS-2	3	Dry	0.01 ± 0.02	Dry	0.01 ± 0.02
WS-3	4	-0.03 ± 0.03	0.01 ± 0.02	Dry	Dry
1-81	6	-0.04 ± 0.03	0.00 ± 0.01	-0.01 ± 0.02	0.01 ± 0.01
2-81	6	-0.05 ± 0.03	0.00 ± 0.01	0.03 ± 0.04	-0.02 ± 0.02
3-81	6	-0.04 ± 0.03	0.01 ± 0.02	0.05 ± 0.06	-0.01 ± 0.01
4-81	1	Dry	Dry	Dry	Dry
5-81	6	-0.03 ± 0.04	-0.01 ± 0.01	0.00 ± 0.02	0.00 ± 0.02
6-81	9	-0.03 ± 0.03	0.00 ± 0.02	0.00 ± 0.01	-0.01 ± 0.02
7-81	9	0.01 ± 0.02	0.01 ± 0.02	Dry	-0.02 ± 0.01
8-81	30	-0.03 ± 0.03	0.00 ± 0.01	0.02 ± 0.02	0.00 ± 0.00
9-81	9	0.01 ± 0.05	0.00 ± 0.02	-0.01 ± 0.02	0.00 ± 0.02
10-81	9	-0.04 ± 0.03	0.01 ± 0.02	0.00 ± 0.01	-0.02 ± 0.02
1-82	6	-0.05 ± 0.03	0.02 ± 0.02	0.01 ± 0.02	-0.01 ± 0.01
2-82	3	Dry	0.02 ± 0.03	0.00 ± 0.02	Dry
3-82	9	-0.05 ± 0.03	-0.01 ± 0.02	0.02 ± 0.02	-0.02 ± 0.02
4-82	9	Dry	Dry	Dry	Dry
5-82	9	-0.03 ± 0.04	-0.01 ± 0.02	0.00 ± 0.01	-0.01 ± 0.01
6-82	9	-0.04 ± 0.03	-0.01 ± 0.01	-0.01 ± 0.02	-0.01 ± 0.02
7-82	9	-0.04 ± 0.03	0.00 ± 0.02	0.02 ± 0.02	0.00 ± 0.02

a. Radiochemically determined as plutonium 239, 240.



LEGEND

● MONITORING WELL GREATER THAN 30 METERS
▲ MONITORING WELL LESS THAN 15 METERS

FIGURE 11. Locations of Groundwater Monitoring Wells at Rocky Flats

All remaining wells range from 1 to 30 m (3 to 100 feet) deep and generally are located near three onsite solar evaporation ponds, certain holding ponds, old burial sites, and a spray irrigation site.

Water samples from the monitoring wells were analyzed for plutonium, uranium, americium, and tritium. Tables 14-17 show the depths of the monitoring wells and radioactivity concentrations for water obtained from each monitoring well during 1983.

Tritium and/or uranium have been detected at low concentrations in monitoring wells close to the solar evaporation ponds that have been used to store process wastewater prior to treatment. These ponds are hydrologically upgradient from the monitoring wells and some seepage has occurred. Monitoring at wells that are in downgradient locations indicate that this seepage is localized.

Water from monitoring wells 15-74, 17-74, 18-74, 3-81, 5-81, and 1-82 had uranium concentrations slightly higher than regional background. Historical data collected since 1975 indicate that the uranium concentrations from wells 15-74, 17-74, and 18-74 are within expected ranges. Data collected since 1981 indicate that the uranium concentrations from monitoring wells 5-81 and 1-82 are within expected ranges. Monitoring well 3-81 is located downstream of monitoring wells 17-74 and 18-74. The uranium may be natural material and not of Rocky Flats Plant origin. Small pockets of low-grade uranium ore are not uncommon in the Arapahoe bedrock formation, which underlies the Plant.

There are no applicable RCG's for groundwater; however, for perspective, the concentrations of plutonium, uranium, americium, and tritium in all samples were well below the DOE and Colorado Department of Health RCG's for water discharged to uncontrolled areas.[2,4]

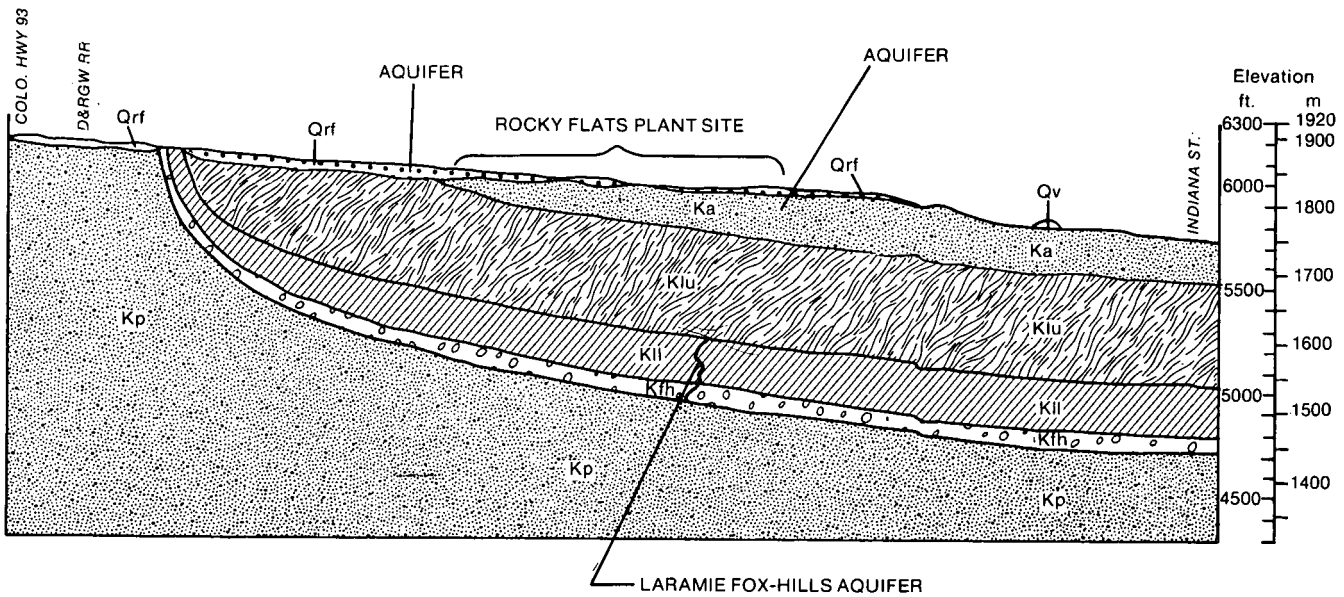
TABLE 13. Uranium Activity Concentrations in Rocky Flats Raw Water Supply

Location	Uranium Concentration ($\times 10^{-9}$ μCi/mℓ) Number of Analyses	C_{min}	C_{max}	C_{avg}	Percent of RCG_w [a]
Rocky Flats Raw Water[b]	12	0.5 ± 0.1	5.4 ± 0.4	1.8 ± 0.1	0.9

a. Radiochemically determined as uranium 233, 234, and 238. The most restrictive Radioactivity Concentration Guide (RCG_w) for these uranium isotopes in the soluble form in water available to the general population is 200×10^{-9} μCi/mℓ.

b. Sources of Raw Water – Ralston Reservoir and South Boulder Diversion Canal.

FIGURE 10. Geologic Cross-Section in the Rocky Flats Plant Area



LEGEND

Qv VERDOS ALLUVIUM

Qrf ROCKY FLATS ALLUVIUM

Ka ARAPAHOE FORMATION

Klu UPPER LARAMIE FORMATION

Kll LOWER LARAMIE FORMATION

Kfh FOX HILLS SANDSTONE

Kp PIERRE SHALE

TABLE 11. Plutonium, Uranium, and Americium Activity Concentrations in Water at the Rocky Flats Plant

Location	Number of Analyses	C_{min}	C_{max}	C_{avg}	Percent of RCG_w
		Plutonium Concentration ($\times 10^{-9}$ μCi/mℓ)[a]			
Pond A-4	31	0.0 ± 0.2	0.12 ± 0.05	0.03 ± 0.01	0.002
Pond B-5	49	-0.05 ± 0.03	0.11 ± 0.04	0.019 ± 0.005	0.001
Pond C-1	51	-0.01 ± 0.01	0.06 ± 0.04	0.012 ± 0.001	<0.001
Pond C-2	9	0.00 ± 0.02	0.06 ± 0.03	0.03 ± 0.01	0.002
Walnut Creek at Indiana Street	42	-0.02 ± 0.01	0.06 ± 0.04	0.014 ± 0.002	<0.001
		Uranium Concentration ($\times 10^{-9}$ μCi/mℓ)[b]			
Pond A-4	31	1.4 ± 0.1	6.2 ± 0.6	2.43 ± 0.04	1.2
Pond B-5	49	2.3 ± 0.3	8.4 ± 0.6	4.73 ± 0.05	2.4
Pond C-1	51	0.05 ± 0.07	5.3 ± 0.4	1.66 ± 0.03	0.8
Pond C-2	9	2.8 ± 0.2	5.0 ± 0.3	4.0 ± 0.1	2.0
Walnut Creek at Indiana Street	42	0.04 ± 0.03	10.6 ± 0.2	4.0 ± 0.1	2.0
		Americium Concentration ($\times 10^{-9}$ μCi/mℓ)[c]			
Pond A-4	31	-0.2 ± 0.1	0.06 ± 0.07	-0.01 ± 0.01	<0.001
Pond B-5	49	-0.09 ± 0.06	0.2 ± 0.2	-0.005 ± 0.008	<0.001
Pond C-1	51	-0.05 ± 0.02	0.05 ± 0.03	0.004 ± 0.003	<0.001
Pond C-2	9	-0.03 ± 0.04	0.08 ± 0.02	0.01 ± 0.02	<0.001
Walnut Creek at Indiana Street	42	-0.04 ± 0.05	0.06 ± 0.09	0.007 ± 0.004	<0.001

a. Radiochemically determined as plutonium 239 and 240. The Radioactivity Concentration Guide(RCG_w) for soluble plutonium in water available to the general population is 1667 $\times 10^{-9}$ μCi/mℓ.
b. Radiochemically determined as uranium 233, 234, and 238. The most restrictive RCG_w for these uranium isotopes in the soluble form in water available to the general population is 200 $\times 10^{-9}$ μCi/mℓ.
c. Radiochemically determined as americium 241. The RCG_w for soluble americium 241 in water available to the general population is 1330 $\times 10^{-9}$ μCi/mℓ.

TABLE 12. Tritium Activity Concentrations in Water at the Rocky Flats Plant

Location	Number of Analyses	Tritium Concentration ($\times 10^{-9}$ μCi/mℓ) C_{min}	C_{max}	C_{avg}	Percent of RCG_w[a]
Pond A-4	31	-500 ± 500	700 ± 500	200 ± 100	0.02
Pond B-5	60	-900 ± 800	700 ± 700	100 ± 100	0.01
Pond C-1	51	-300 ± 600	600 ± 800	200 ± 100	0.02
Pond C-2	9	-200 ± 500	500 ± 500	200 ± 200	0.02
Walnut Creek at Indiana Street	42	-900 ± 900	1100 ± 700	200 ± 100	0.02

a. The Radioactivity Concentration Guide (RCG_w) for tritium in water available to the general population is 1,000,000 $\times 10^{-9}$ μCi/mℓ.

were no violations of the NPDES permit during 1983.

Prior to discharge from Ponds A-4, B-5, and C-2, the water is sampled and analyzed for gross alpha, gross beta, tritium, gamma activity, pH, nitrate as N, and nonvolatile suspended solids. The water will not be discharged if the Plant action level for any parameter is exceeded.

During discharges from Ponds A-4, B-5, and C-2 in 1983, the water was sampled continuously. The samples were analyzed for plutonium, uranium, americium, tritium, pH, nitrate as N, and nonvolatile suspended solids. Water is also sampled continuously and collected daily from the outfall of Pond C-1 and collected from the Walnut Creek at Indiana Street sampling station when there is sufficient flow. Daily samples were composited into weekly samples for plutonium, uranium, and americium analyses. Once each week, daily samples at Pond C-1 and Walnut Creek at Indiana are analyzed for tritium. Concentrations of plutonium, uranium, americium, and tritium in water samples from the outfalls of Ponds A-4, B-5, C-1, C-2, and from Walnut Creek at Indiana Street are presented in Tables 11 and 12. All plutonium, uranium, americium, and tritium concentrations at these locations were 2.4 percent or less of the applicable Radioactivity Concentration Guides (RCG_W).[2,4]

The Rocky Flats Plant water supply was taken from two sources during the year—Ralston Reservoir and South Boulder Diversion Canal. Ralston Reservoir is located near the Schwartzwalder uranium mine, and the water usually contains more uranium radioactivity than does water from the South Boulder Diversion Canal, which flows from the Moffat Tunnel. During the year, monthly uranium analyses were performed on samples of Rocky Flats raw water. The uranium concentrations measured during 1983 are presented in Table 13. Uranium concentrations measured during 1983 in raw water averaged 0.07 Bq/ℓ (1.8×10^{-9} μCi/mℓ).

Biocides and herbicides are used for pest and weed control on the Rocky Flats Plant site, and water samples are collected from Ponds B-4 and C-1 during application. Analytical results for the materials used, 2,4-D and Bromacil, have consistently been less than 2 parts per billion. The recommended concentration limit for these materials is 100 parts per billion.

Approximately 410 gallons of polychlorinated biphenyls (PCB's) containing low-level plutonium radioactivity are stored at the Rocky Flats Plant. The EPA has been requested to approve a plan for removal. Some operating transformers contain PCB's, and each is identified and protected according to EPA regulations. Analytical results from downstream waters during 1983 showed no concentrations of PCB's above a concentration of approximately 1 part per billion.

E. Groundwater Monitoring

Groundwater occurs in the Rocky Flats alluvium, Arapahoe Formation, and the Laramie-Fox Hills aquifer. (See Figure 10.) The Rocky Flats alluvium consists primarily of clay, silt, sand, and gravel. The Laramie Formation is divisible into two units—a lower sandstone unit and an upper shale unit. The lower sandstone unit and the Fox Hills sandstone are collectively referred to as the Laramie-Fox Hills aquifer.

During 1983, samples from monitoring wells shown in Figure 11 were analyzed to determine significant movement of chemical or radioactive materials of possible Plant origin into water-bearing strata underlying the site.

Five of the monitoring wells range from 43 to 96 meters (140 to 320 feet) in depth. These monitoring wells, numbered 1-66, 2-66, 3-66, 21-74, and 22-74, are located respectively: west of the west security fence, northeast of the solar ponds, east of the solar ponds, near the south security fence, and east of the east security fence. These wells provide information concerning water quality in gravel and bedrock formations.

Seven new monitoring wells were drilled in 1982. Two of these wells, 1-82 and 2-82, are 6 m (20 feet) and 3 m (10 feet) deep, respectively, and were drilled to monitor water near a drainage area. The other new monitoring wells, 3-82, 4-82, 5-82, 6-82, and 7-82 are 10 m (30 feet) deep and were drilled to monitor groundwater near a spray irrigation site.

TABLE 10. Annual Average Concentrations of Chemical and Biological Constituents in Liquid Effluents[a]

Parameter	Number of Analyses	C_{min}	C_{max}	C_{avg}
Discharge 001[b]				
pH, SU[c]	2	7.6	8.1	–
Nitrate as N, mg/ℓ	2	2.0	2.1	2.0
Total Suspended Solids, mg/ℓ	2	2.0	25.0	13.5
Total Residual Chlorine, mg/ℓ	5	0.1	0.2	0.1
Total Chromium, mg/ℓ	1	<0.05	<0.05	<0.05
Total Phosphorus, mg/ℓ	2	0.7	0.7	0.7
Fecal Coliform, #/100 mℓ	2	2.2	2.2	2.2
Biochemical Oxygen Demand (BOD_5), mg/ℓ	1	5.1	5.1	5.1
Discharge 002[b]				
pH, SU	19	6.7	8.5	–
Nitrates as N	19	1.3	8.4	3.6
Discharge 003[b]				
During 1983, no discharges were made to offsite waters				
Discharge 004[b]				
During 1983, no discharges were made to offsite waters				
Discharge 005[b]				
pH, SU	31	7.4	9.0	–
Nitrates as N, mg/ℓ	31	0.3	14.0	4.0
Nonvolatile Suspended Solids, mg/ℓ	31	0.0	119	19.7
Discharge 006[b]				
pH,SU	60	7.3	8.5	–
Nitrates as N, mg/ℓ	60	<0.2	6.7	<1.7
Nonvolatile Suspended Solids, mg/ℓ	60	1.0	556	48.0
Discharge 007[b]				
pH, SU	9	7.6	8.3	–
Nitrates as N, mg/ℓ	9	<0.2	<0.2	<0.2
Nonvolatile Suspended Solids, mg/ℓ	9	1.0	70	12.4

a. Examples of NPDES Permit limitations are presented in Table A-1.
b. The Environmental Protection Agency NPDES discharge permit defines the discharge locations as follows:
001 - Pond B-3
002 - Pond A-3
003 - Reverse Osmosis Pilot Plant
004 - Reverse Osmosis Plant
005 - Pond A-4
006 - Pond B-5
007 - Pond C-2
c. SU - Standard Units

B-3, B-5, and C-2 during 1983 are presented in Table 10. The data are indicative of overall water quality from these ponds.

During 1981, the original Plant NPDES permit expired and was replaced by a new NPDES permit with seven discharge locations–001, 002, 003, 004, 005, 006, and 007. The discharge locations are identified in Table 10. The NPDES permit places monitoring and reporting requirements and limitations on daily concentrations and monthly average concentrations for some specific parameters. There

28

percent of the EPA annual mean standard of 0.030 ppm. The maximum observed 24-hour average for SO_2 was 0.016 ppm, which is 11 percent of the EPA 24-hour standard of 0.140 ppm.

The 5,706 hourly averages of carbon monoxide (CO) data collected since March, 23, 1983, using a newly installed gas filter correlation type analyzer, showed an annual arithmetic mean of 0.62 ppm, including a maximum 1-hour average value of 12.6 ppm, which is 36 percent of the annual Mean Standard of 35 ppm. A maximum 8-hour average concentration value of 8.4 ppm was recorded, which is 93 percent of the 8-hour Primary Standard of 9 ppm. The CO analyzer was calibrated, using a high-quality standard cylinder gas, which has traceability to NBS Standards.

The limited nitrogen dioxide (NO_2) data contain 40 days of continuous sampling and show an arithmetic mean of 0.014 ppm, which is 28 percent of the Primary Mean Standard value of 0.05 ppm. The maximum 1-hour value noted during this time period was 0.057 ppm. Calibration of the NO_2 analyzer included calibrating the NO_x and NO channels using a standard cylinder gas, and then implementing gas phase titration techniques for the subtractive NO_2 channel. The analyzer is challenged biweekly with NO_2 test gas from a calibrated NO_2 permeation tube and a dynamic gas blending system with flow meters that have traceability to Primary Flow Standards.

The data for all parameters were assessed with an accuracy of ±13 percent based on routine precision and operational span checks, multipoint dynamic calibrations, and established quality assurance procedures.

D. Waterborne Effluent Monitoring

North Walnut Creek receives stormwater runoff from the north side of the Plant site. (See Figure 4.) Holding Pond A-3 on North Walnut Creek is used to impound this surface runoff for analysis prior to discharge. A second control point, holding Pond A-4, is located further downstream.

Ponds A-1 and A-2 are isolated by valves from North Walnut Creek. In the past, these ponds have been used for storage and evaporation of laundry water. This practice was discontinued during 1980. These ponds currently are maintained in a state of readiness for control of possible chemical spills into the North Walnut Creek drainage. Disposition of Pond A-1 and A-2 precipitation water is through natural evaporation and is enhanced by spraying water through fog nozzles over the surface of the ponds. Excess water that does not evaporate is then recollected by the ponds.

South Walnut Creek receives stormwater runoff from the central portion of the Plant. This water is diverted through a culvert system to Pond B-4 and then to Pond B-5 where the water is impounded for analysis prior to controlled offsite discharge.

In the past, treated sanitary wastewater was also discharged routinely to South Walnut Creek. This practice was discontinued in 1979. During May 1983, excessive rainfall necessitated a five-day monitored discharge of treated sanitary wastewater through the ponds located along the south Walnut Creek watercourse. During 1981, 1982, and 1983, some treated sanitary wastewater was recycled through the Plant Reverse Osmosis (RO) Facility for further treatment and was reused in Plant cooling towers. Excess water that could not be recycled was discharged directly to Pond B-3 or pumped into the RO holding ponds and was spray-irrigated onto Rocky Flats soil (Figure 7). Ponds B-1 and B-2, also located in the central drainage, are reserved as backup control ponds. These ponds can be used to retain chemical spills, surface water runoff, or treated sanitary wastewater of questionable quality.

Surface runoff water from the south side of the Plant is collected in an interceptor ditch and flows to surface water control Pond C-2, where the water is impounded and analyzed before discharge to offsite receiving waters. Woman Creek, also in the south drainage, is isolated from this system. Pond C-1 is used as a monitoring point for Woman Creek.

Discharges from the Rocky Flats Plant are monitored for compliance with appropriate Colorado Department of Health standards and EPA NPDES permit limitations.[7] Annual average concentrations of chemical and biological constituents of liquid effluent samples collected from Ponds A-3, A-4,

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TABLE 9. Onsite MAAM Van Ambient Air Quality Data (Nonradioactive)

Total Suspended Particulates ($\mu g/m^3$)	
Total Number of Samples - "A"[a]	55
Total Number of Samples - "B"[b]	50
Geometric Mean, Sampler "A"	52
Geometric Mean, Sampler "B"	52
Standard Deviation, Sampler "A"	29.71
Standard Deviation, Sampler "B"	30.19
Observed 24-Hour Maximum, "A"	196
Observed 24-Hour Maximum, "B"	195
Second Highest Maximum, "A"	112
Second Highest Maximum, "B"	115
Lowest Observed Value, "A"	13
Lowest Observed Value, "B"	8
Ozone (ppm)	
Number of Observations, Hourly	7,923
Arithmetic Mean, Annual	0.036
Maximum 1-Hour Concentration	0.177
Second Highest 1-Hour Concentration	0.149
Minimum Observation, Hourly	0.002
Carbon Monoxide (ppm)	
Number of Observations, Hourly	5,706
Arithmetic Mean, Annual	0.62
Maximum 1-Hour Concentration	12.6
Maximum 8-Hour Concentration	8.4
Nitrogen Dioxide (ppm)	
Number of Observations, Daily	40
Arithmetic Mean	0.14
Maximum 1-Hour Concentration	0.057
Sulfur Dioxide (ppm)	
Number of Observations, Hourly	7,219
Arithmetic Mean, Annual	0.003
3-Hour Average, Highest	0.025
24-Hour Average, Highest	0.016
Maximum 1-Hour Concentration	0.039

Airborne Lead ($\mu g/m^3$)

	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec
Total Number of Samples	6	8	6	6
Quarterly Avg.	0.0223	0.0071	0.0362	0.0333

a. Primary ambient air particulate sampler.
b. Co-located duplicate sampler.

year, with the exception of carbon monoxide data collection, which began in March, and nitrogen dioxide data collection which began in November. These data are shown in Table 9.

Total suspended particulate measurements and lead measurements were conducted using the EPA Reference Hi-Vol method. The primary ambient air particulate sampler and a co-located duplicate sampler are located on top of the MAAM van and are operated on the EPA once-every-sixth day sampling schedule. The highest TSP value recorded (a 24-hour sample) was 196 $\mu g/m^3$ which is 75 percent of the primary 24-hour standard of 260 $\mu g/m^3$. The calculated annual geometric mean value for TSP was 52 $\mu g/m^3$, which is 69 percent of the annual Geometric Primary Standard of 75 $\mu g/m^3$. This number corresponds with mean values reported by the Colorado Department of Health. The CDH routinely performs TSP measurements at the southeastern Plant boundary at Woman Creek and Indiana Street. Historically, these measurements have shown annual average particulate levels ranging from about 30 to 66 $\mu g/m^3$, which are well below the NAAQS. The quarterly average lead concentrations for the four quarters of 1983 were 0.0223 $\mu g/m^3$, 0.0071 $\mu g/m^3$, 0.0362 $\mu g/m^3$, and 0.0333 $\mu g/m^3$, respectively. These values are less than 3 percent of the primary standard of 1.5 $\mu g/m^3$

The Chemiluminescent O_3 analyzer was calibrated by use of a Primary UV Photometer Standard, with traceability to an EPA Primary UV Photometer. A minimum quarterly calibration schedule was conducted, with increased frequency implemented as needed, based on biweekly performance of zero and span checks. A total of 7,923 1-hour ozone samples was collected. The maximum 1-hour value was 0.177 ppm, which is 147 percent of the Primary One-Hour Standard of 0.120 ppm. This value is consistent with levels seen in the general Denver metropolitan area.

Sulfur dioxide sampling was conducted using a continuously operating pulsed fluorescence type analyzer, calibrated with a temperature-controlled permeation tube-type calibration system. The permeation tube and associated flow rates have calibrations traceable to standards set by the National Bureau of Standards. The maximum 1-hour SO_2 value recorded at the Plant was 0.039 ppm and the maximum observed 3-hour average value was 0.025 ppm, which is 5 percent of the EPA 3-hour standard of 0.500 ppm. The calculated annual arithmetic mean value of 0.003 ppm is 10

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TABLE 8. Mobile Ambient Air Monitoring (MAAM) Van Detection Methods and National Air Quality Standards (NAAQS) for Total Suspended Particulates, Ozone, Sulfur Dioxide, Carbon Monoxide, Nitrogen Dioxide, and Lead

Parameter	Detection Methods and Analyzer Ranges	NAAQS Averaging Time	Concentration
Total Suspended Particulates (TSP)	Reference Method (Hi Volume) 24-Hour sampling (6th-day scheduling)	Annual Geometric Mean: Primary[a] Secondary[b]	 75 $\mu g/m^3$ 60 $\mu g/m^3$
		24-Hour Primary[a,c] Secondary[b,c]	 260 $\mu g/m^3$ 150 $\mu g/m^3$
Ozone (O_3)	Beckman Model 950 Chemiluminescent 0–0.5 ppm	1-Hour Primary[a,d]	 0.12 ppm
Sulfur Dioxide (SO_2)	ThermoElectron Model 43 Pulsed Fluorescence 0-0.5 ppm	Annual Arithmetic Mean: Primary[a]	 0.030 ppm
		24-Hour Primary[a,c]	 0.140 ppm
		3-Hour Secondary[b,c]	 0.500 ppm
Carbon Monoxide (CO)	ThermoElectron Model 48 Gas Filter Correlation (infrared) 0-50 ppm	1-Hour Primary[a,c]	 35 ppm
		8-Hour Primary[a,c]	 9 ppm
Nitrogen Dioxide (NO_2)	Monitor Labs Model 8840 Chemiluminescent 0-0.5 ppm	Annual Arithmetic Mean: Primary[a]	 0.05 ppm
Lead	Reference Method (Hi Volume) 24-Hour Sampling (Atomic Absorption Analysis)	Calendar Quarter Primary[a]	 1.5 $\mu g/m^3$

a. Primary NAAQS are intended to protect public health.
b. Secondary NAAQS are intended to protect public welfare.
c. Not to be exceeded more than once per year.
d. Statistically estimated number of days with concentrations in excess of the standard is not to be more than 1.0 per year.

TABLE 7. Plutonium 239 and 240 Activity Concentrations in Community Ambient Air

Station	Number of Analyses	Volume (X 1000 m^3)	Concentration (X 10^{-15} μCi/mℓ) C_{min} LCL	C_{min} Point Estimate	C_{min} UCL	C_{max} LCL	C_{max} Point Estimate	C_{max} UCL	C_{avg} LCL	C_{avg} Point Estimate	C_{avg} UCL	Percent[a] of RCG_a
Marshall	12	370	0.000	0.001	0.003	0.006	0.011	0.017	0.004	0.004	0.005	0.02
Jeffco Airport	12	339	-0.002	0.000	0.002	0.005	0.014	0.024	0.003	0.004	0.005	0.02
Superior	12	319	-0.004	-0.001	0.001	0.454	0.528	0.617	0.035	0.038	0.042	0.19
Boulder	11	401	-0.028	-0.010	0.008	0.006	0.009	0.013	0.001	0.003	0.004	0.02
Lafayette	12	369	-0.009	0.004	0.001	0.009	0.013	0.018	0.003	0.003	0.004	0.02
Broomfield	11	309	-0.003	0.000	0.002	0.004	0.008	0.011	0.002	0.003	0.004	0.02
Walnut Creek	12	373	-0.001	0.001	0.003	0.008	0.011	0.016	0.003	0.004	0.005	0.02
Wagner	12	382	-0.003	-0.001	0.002	0.004	0.008	0.013	0.002	0.003	0.004	0.02
Leyden	12	384	-0.004	-0.001	0.001	0.002	0.011	0.020	0.002	0.003	0.004	0.02
Westminster	12	349	-0.003	0.000	0.002	0.004	0.008	0.012	0.001	0.002	0.003	0.01
Denver	12	371	-0.003	0.000	0.003	0.176	0.200	0.229	0.016	0.018	0.019	0.09
Golden	12	368	-0.001	0.000	0.002	0.003	0.008	0.013	0.003	0.004	0.005	0.02
Cotton Creek[b]	11	346	-0.001	0.002	0.004	0.010	0.015	0.019	0.004	0.005	0.006	0.03
Summary	153	–	–	-0.010	–	–	0.528	–	–	–	–	–
Average Concentration	–	–	–	–	–	–	–	–	–	0.007	–	0.04

a. The Radioactivity Concentration Guide (RCG_a) for soluble plutonium in ambient air available to the general population is 20 X 10^{-15} μCi/mℓ.
b. New Community Sampler installed February 1983.

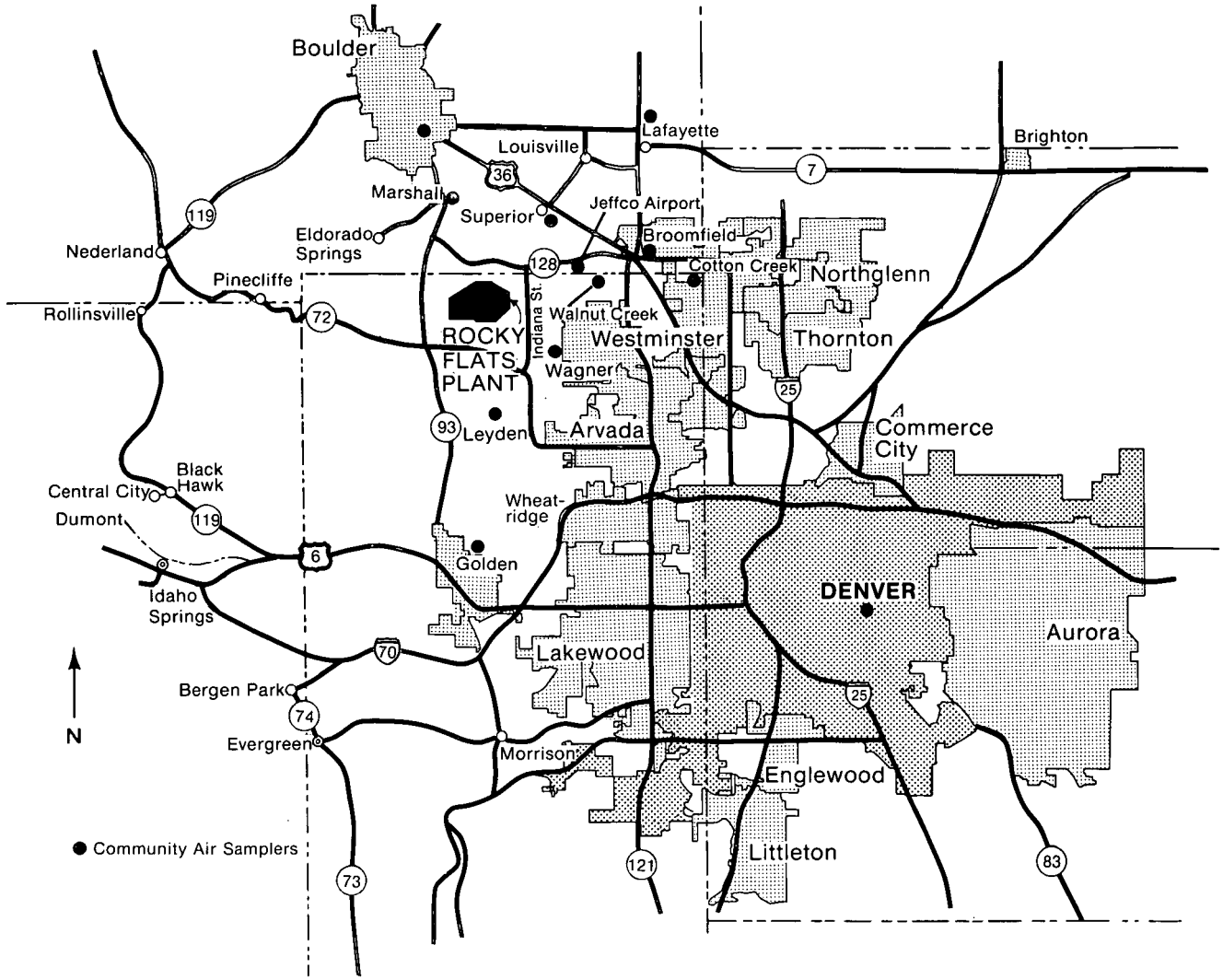

FIGURE 9. Location of Community Ambient Air Samplers

TABLE 6. Plutonium 239 and 240 Activity Concentrations in Perimeter Ambient Air

Station	Number of Analyses	Volume (× 1000 m³)	Concentration (× 10^{-15} μCi/mℓ) C_{min} LCL	C_{min} Point Estimate	C_{min} UCL	C_{max} LCL	C_{max} Point Estimate	C_{max} UCL	C_{avg} LCL	C_{avg} Point Estimate	C_{avg} UCL	Percent[a] of RCG_a
S-31	12	413	-0.003	-0.001	0.002	0.004	0.007	0.010	0.001	0.002	0.003	0.01
S-32	12	353	-0.003	-0.001	0.001	0.002	0.006	0.011	0.002	0.002	0.003	0.01
S-33	12	406	-0.002	0.000	0.002	0.005	0.008	0.012	0.002	0.002	0.003	0.01
S-34	12	394	-0.001	0.002	0.005	0.005	0.009	0.012	0.003	0.004	0.005	0.02
S-35	12	367	-0.003	-0.001	0.001	0.003	0.005	0.008	0.001	0.002	0.003	0.01
S-36	12	402	-0.003	0.000	0.003	0.001	0.016	0.021	0.003	0.004	0.005	0.02
S-37	12	378	-0.003	-0.001	0.000	0.003	0.008	0.013	0.004	0.005	0.005	0.03
S-38	12	342	-0.002	0.000	0.001	0.012	0.019	0.025	0.004	0.005	0.006	0.03
S-39	12	387	-0.001	0.000	0.001	0.003	0.007	0.011	0.002	0.003	0.004	0.02
S-40	12	368	-0.004	-0.002	0.000	0.006	0.010	0.014	0.002	0.003	0.004	0.02
S-41	12	342	-0.005	-0.003	0.000	0.007	0.011	0.016	0.003	0.004	0.004	0.02
S-42	12	376	-0.001	0.001	0.003	0.008	0.013	0.017	0.003	0.003	0.004	0.02
S-43	12	278	-0.005	-0.001	0.002	0.009	0.015	0.023	0.003	0.004	0.005	0.02
S-44	12	382	-0.002	-0.001	0.001	0.001	0.019	0.025	0.003	0.004	0.004	0.02
Summary	168	–	–	-0.003	–	–	0.019	–	–	–	–	–
Average Concentration		–	–	–	–	–	–	–	–	0.003	–	0.02

a. The Radioactivity Concentration Guide (RCG_a) for soluble plutonium in ambient air available to the general population is 20 × 10^{-15} μCi/mℓ.

collected biweekly, composited by location, and analyzed for a 4-week period for plutonium radioactivity.

Table 7 presents the average concentrations of plutonium in airborne particulates at the community stations during 1983. The Denver and Superior locations each include one anomalous value. Statistical models applied to a 3-year data set, including 1,154 perimeter and community average concentrations, indicate that these two values are outliers that are not indicative of true ambient air plutonium concentrations. It is believed that these two outliers resulted from sample cross-contamination during preparation for analysis. This cannot be proved, and these two anomalous values have been included. The average concentration of plutonium in ambient air at the community stations was 2.59 × 10^{-7} Bq/m³ (0.007 × 10^{-15} μCi/mℓ). This value is 0.04 percent of the soluble plutonium RCG_a for the general population.[2,4]

C. Nonradioactive Ambient Air Monitoring

During 1983, monitoring of ambient air included the following: total suspended particulates (TSP), ozone, sulfur dioxide, carbon monoxide, nitrogen dioxide, and lead. This monitoring utilized instrumentation in a self-contained van equipped for mobile ambient air monitoring (MAAM). These six parameters are criteria pollutants regulated by the EPA and the State of Colorado through the Clean Air Act of 1970 which includes the National Ambient Air Quality Standards (NAAQS) and Colorado Air Quality Control Commission Ambient Air Standards. Table 8 identifies the detection methods and operating ranges of the MAAM monitoring analyzers with corresponding compliance standards. During 1983, the van remained stationary at a location near the east entrance to the Plant. This is an open area near a traffic zone and is generally downwind from Plant buildings. Ambient air data were collected over the entire

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TABLE 4. Plutonium 239 and 240 Activity Concentrations in Onsite Ambient Air at Selected Locations[a]

Station	Number of Analyses	Volume (× 1000 m³)	Concentration[b] (× 10^{-15} μCi/mℓ) C_{min}[c] LCL[d]	C_{min} Point Estimate	C_{min} UCL[e]	C_{max} LCL	C_{max} Point Estimate	C_{max} UCL	C_{avg} LCL	C_{avg} Point Estimate	C_{avg} UCL	Percent of RCG_a[f]
S-5	26	380	0.006	0.012	0.017	0.058	0.069	0.081	0.034	0.036	0.039	0.06
S-6	25	365	0.005	0.010	0.015	0.284	0.329	0.382	0.049	0.052	0.054	0.09
S-7	26	356	0.041	0.058	0.075	0.834	0.921	1.019	0.282	0.292	0.302	0.49
S-8	26	383	0.075	0.093	0.112	1.191	1.293	1.409	0.418	0.430	0.443	0.72
S-9	26	356	0.090	0.109	0.129	0.491	0.548	0.612	0.308	0.318	0.328	0.53

a. These selected air-sampling locations are in the proximity of areas where potential for airborne radioactivity exists (see Figure 8).
b. Two-week composites of station concentrations.
c. C_{min} = Minimum measured concentration; C_{max} = Maximum measured concentration; C_{avg} = Average measured concentration.
d. LCL = Lower Confidence Limit.
e. UCL = Upper Confidence Limit.
f. The Radioactivity Concentration Guide (RCG_a) for soluble plutonium in ambient air available to an individual in the general population is 60 × 10^{-15} μCi/mℓ.

TABLE 5. Tritium Activity Concentrations in Onsite Ambient Air Water Vapor

Station	Number of Analyses	Concentration (× 10^{-9} μCi/mℓ) C_{min}	C_{max}	C_{avg}[a]	Percent of RCG_w[b]
S-4	50	-50 ± 300	600 ± 250	<200 ± 250	<0.007
S-5	48	-200 ± 250	450 ± 250	<400 ± 250	<0.003
S-16	50	-50 ± 300	550 ± 250	<150 ± 250	<0.005

a. The average tritium concentrations are less than 2.0 percent of the EPA and State of Colorado primary drinking water limits of 20,000 × 10^{-9} μCi/mℓ.
b. The Radioactivity Concentration Guide (RCG_w) for tritium in water available to an individual in the general population is 3,000,000 × 10^{-9} μCi/mℓ.

Samples of airborne particulates are collected on filters by high-volume air samplers at 14 locations along or near the Plant perimeter. These perimeter samplers are located between 3 and 6 km (2 and 4 mi) from the Plant center. (See Figure 8). The samplers are numbered S-31 through S-44. Samples from each location are collected biweekly, composited by location, and analyzed for a 4-week period for plutonium. Table 6 presents the average concentrations of plutonium radioactivity in airborne particulates at Stations S-31 through S-44 during 1983. The average concentration of plutonium in ambient air at these locations during 1983 was 1.11 × 10^{-7} Bq/m³ (0.003 × 10^{-15} μCi/mℓ). This concentration was 0.02 percent of the soluble plutonium RCG_a for the general population.[2,4]

Samples of airborne particulates are also collected at 13 locations in or near communities in the vicinity of the Rocky Flats Plant. These locations, shown in Figure 9, are Boulder, Broomfield, Cotton Creek, Denver, Golden, Jeffco Airport, Lafayette, Leyden, Marshall, Superior, Wagner, Walnut Creek, and Westminster. Sample filters are

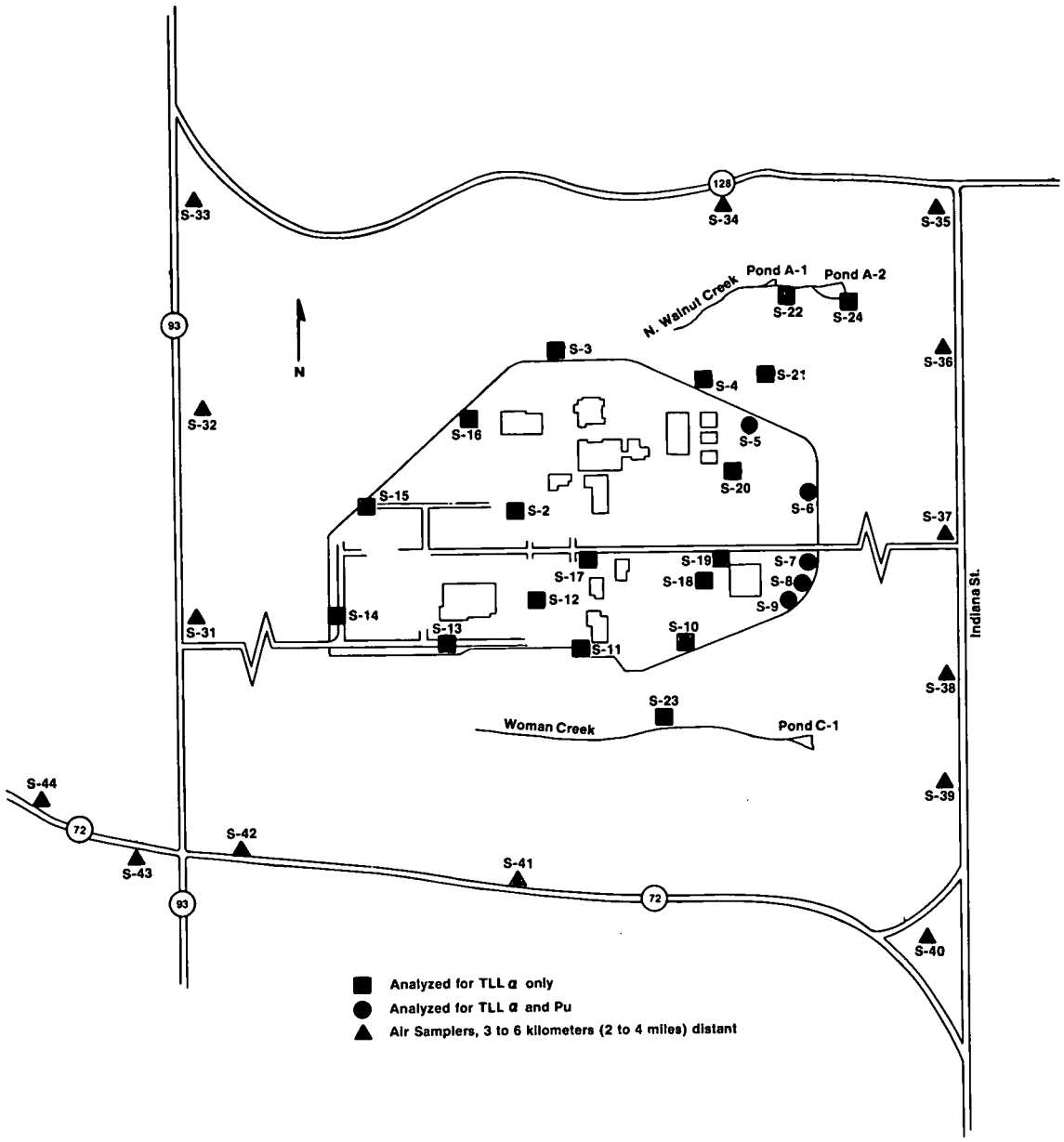

FIGURE 8. Location of Onsite and Plant Perimeter Ambient Air Samplers
(Portions of figure are not to scale.)

TABLE 3. Beryllium in Airborne Effluents

Sample Period	Number of Analyses	Total Discharge[a] (g)	C_{max} ($\mu g/m^3$)
January	50	0.003	0.0006
February	49	-0.019	0.0002
March	44	-0.016	0.0011
April	44	-0.022	0.0006
May	44	0.019	0.0003
June	45	0.006	0.0026
July	53	-0.008	0.0009
August	45	-0.064	0.0006
September	43	0.001	0.0002
October	46	-0.022	0.0003
November	50	0.022	0.0005
December	43	-0.001	0.0002
Summary	556	-0.101[b]	0.0026

a. The beryllium stationary-source emission-standard is no more than 10 grams of beryllium over a 24-hour period under the provision in subpart C of 40 CFR 61.32(a).[12]
b. This value is indistinguishable from the background associated with the analyses.

Table 3 presents the beryllium airborne effluent data for 1983. The total quantity of beryllium discharged from the 43 ventilation exhaust systems was indistinguishable from the background associated with the analyses.

B. Radioactive Ambient Air Monitoring

High-volume ambient air samplers are located on the Rocky Flats Plant site, at the Plant perimeter [a distance of approximately 3 to 6 km (2 to 4 mi) from the Plant center], and in surrounding communities. These Rocky Flats–designed air samplers operate continuously at a volume flow rate of approximately 19 ℓ/sec (40 ft^3/min), collecting particulates on 20- X 25-cm (8- X 10-in.) Schleicher and Schuell, S&S 29 filter media. Manufacturer's test specifications rate this filter media to be 99.97% efficient for the relevant particle sizes under conditions typically encountered in routine ambient air sampling.[13]

Airborne particulates in ambient air are sampled continuously at 23 locations within and adjacent to the Rocky Flats exclusion area (Figure 8). The sample filters are collected biweekly and analyzed for total long-lived alpha (TLLα). If the TLLα concentration for an ambient air sample exceeds the Plant guide value [3.7×10^{-4} Bq/m^3 (10×10^{-15} μCi/mℓ)], specific plutonium analysis is performed. During 1983, all TLLα concentrations were less than the guide value.

On a routine basis, filters from 5 of the 23 samplers are composited and analyzed biweekly for plutonium. Table 4 contains the average concentrations of plutonium in ambient air at these five onsite stations during 1983. The calculated value for the average concentration at each location is referred to as the "point estimate." For each plutonium concentration point estimate, a Lower Confidence Limit (LCL) and an Upper Confidence Limit (UCL), which define a 95 percent confidence interval, have been included in the table. The derivation of the point estimates, the LCL, and the UCL is discussed in Appendix E. The average concentrations of plutonium in ambient air at the five onsite stations during 1983 ranged from 1.33×10^{-6} to 1.59×10^{-5} Bq/m^3 (0.036×10^{-15} to 0.430×10^{-15} μCi/mℓ. These concentrations were less than 0.72 percent of the RCG_a for soluble plutonium in ambient air available to an individual in the general population.[2,4]

Monitoring for tritium in ambient-air water vapor is conducted at onsite locations S-4, S-5, and S-16 (Figure 8). Samples are collected and analyzed weekly. The tritium sampler utilizes a 1 ℓ/min air pump that operates continuously. The sample is collected in a Pyrex tube filled with silica gel, which collects moisture from the ambient air. The equipment is contained in an aluminum case that is insulated, weathertight, and lockable. Temperature inside the case is controlled by a small heater and fan that maintain a temperature between 4.44 and 32.2 °C (40 and 90 °F). Table 5 presents the average concentrations of tritium in ambient air water vapor at these three onsite stations during 1983. The maximum average concentration of tritium in ambient air at the three onsite stations during 1983 was less than 14.8 Bq/ℓ (400×10^{-9} μCi/mℓ). This concentration was less than 0.04 percent of the RCG_w for tritium in water released to uncontrolled areas.[2,4]

TABLE 2. Radioisotopes in Airborne Effluents CY 83

Sample Period	Plutonium[a] Number of Analyses	Plutonium Total Discharge (μCi)	Plutonium C_{max}[c] ($\times 10^{-12}$ μCi/mℓ)	Uranium[b] Number of Analyses	Uranium Total Discharge (μCi)	Uranium C_{max} ($\times 10^{-12}$ μCi/mℓ)	Tritium Number of Analyses	Tritium Total Discharge (Ci)	Tritium C_{max} ($\times 10^{-12}$ μCi/mℓ)
January	40	0.86	0.055 ± 0.006	50	3.47	0.063 ± 0.020	299	0.020	160 ± 80
February	38	1.02	0.0080 ± 0.0004	49	2.59	0.173 ± 0.023	276	0.007	490 ± 70
March	35	1.47	0.0057 ± 0.0004	44	3.53	0.026 ± 0.014	299	0.021	3560 ± 200
April	36	1.11	0.039 ± 0.005	44	3.99	0.010 ± 0.002	294	0.018	270 ± 50
May	35	0.84	0.023 ± 0.002	44	3.14	0.032 ± 0.001	277	0.015	500 ± 250
June	35	0.77	0.0026 ± 0.0002	45	5.42	1.180 ± 0.004	308	0.012	170 ± 85
July	42	66.77	2.96 ± 0.64	53	5.92	0.048 ± 0.005	276	0.005	150 ± 75
August	37	2.10	0.0083 ± 0.0006	45	6.57	0.121 ± 0.029	322	0.014	250 ± 150
September	35	0.73	0.0030 ± 0.0003	43	4.31	0.021 ± 0.004	253	0.022	150 ± 55
October	36	1.22	0.0071 ± 0.0006	46	5.29	0.100 ± 0.032	322	0.027	110 ± 55
November	40	0.37	0.037 ± 0.004	50	4.57	0.349 ± 0.034	276	0.000	170 ± 50
December	36	0.84	0.026 ± 0.004	43	2.21	0.0082 ± 0.0007	242	0.004	90 ± 30
Summary	445	78.10	2.96 ± 0.64	556	51.01	1.180 ± 0.004	3444	0.165	3560 ± 200

a. Radiochemically determined as plutonium 239, 240.
b. Radiochemically determined as uranium 233, 234, and 238.
c. C_{max} is the maximum measured concentration.

specific alpha-emitting radionuclides. Analyses for uranium isotopes are conducted on the composite samples from each of the 43 exhaust systems. Thirty-five of the ventilation exhaust systems are located in buildings that contain plutonium. Particulate samples from those 35 systems are also analyzed for specific isotopes of plutonium.

Continuous sampling for tritium is conducted in 23 ventilation exhaust systems. A bubbler-type sampler is used to collect samples three times each week. Tritium concentrations in the sample are measured on a liquid scintillation photospectrometer.

Table 2 presents the quantitative data for radioisotopes in airborne effluents during 1983. Tritium values include contributions from background radioactivity.

During 1983, the total quantity of plutonium discharged to the atmosphere from 35 ventilation exhaust systems was less than 2.89×10^6 Bq (78.10 μCi).

The maximum plutonium concentration of 0.1095 Bq/m^3 (2.96×10^{-12} μCi/mℓ) was measured during a three-day period in July from an exhaust system in a chemical processing building. The quantity of plutonium from this discharge [2.41×10^6 Bq (65.33 μCi)] presented no adverse environmental impact. Samples collected prior to, and following, this three-day period were within the range typically measured in this exhaust system. The total discharge of uranium from 43 exhaust systems was less than 1.89×10^6 Bq (51.01 μCi). The maximum uranium concentration of 4.366×10^{-2} Bq/m^3 (1.180×10^{-12} μCi/mℓ) was measured during a 2-day period in June from an exhaust system that discharges small volumes of air, compared to most other systems at the plant. The quantity of uranium from this discharge [~3.933×10^4 Bq (1.063 μCi)] presented no adverse environmental impact. The tritium discharged from 23 ventilation systems was 6.106×10^9 Bq (0.165 Ci).

Overall, the 1983 data were in the normal ranges projected in the Plant Impact Statement; and presented no adverse environmental impact.

boundary, the maximum 70-year dose commitment to an individual was calculated to be 5×10^{-7} Sv* (5×10^{-5} rem) to the total body and 3×10^{-6} Sv (3×10^{-4} rem) to the bone. By comparison, annual doses to the body and bone from natural radiation in the Denver area are 1.50×10^{-3} and 1.68×10^{-3} Sv (1.5×10^{-1} and 1.68×10^{-1} rem/yr), respectively.[10] The 70-year dose commitments of 5×10^{-7} and 3×10^{-6} Sv (5×10^{-5} and 3×10^{-4} rem) represent less than 0.01 percent and less than 0.02 percent, respectively, of the DOE and CDH radiation protection standards.[2,4]

For community locations, the maximum radiation dose resulted in a 70-year dose commitment of 3.3×10^{-8} Sv (3.3×10^{-6} rem) to the total body and 9.5×10^{-6} Sv (9.5×10^{-4} rem) to the bone. This represents less than 0.002 percent and less than 0.2 percent, respectively, of the annual DOE standards[2] based on average dose for a suitable sample of the exposed population. These values include contribution from fallout caused by atmospheric weapons testing. The 70-year total body dose commitment to the population living within 80 kilometers (50 miles) of the Plant was based on the maximum community dose estimates. For the maximum community, the specific organ doses were all less than the 1 millirem-per-year value specified by DOE as *de minimis* (inconsequential). The dose commitment for all individuals to a distance of 80 kilometers was, therefore, considered to be *de minimis.*

IV. MONITORING DATA: COLLECTION, ANALYSES, AND EVALUATION

This section describes the environmental monitoring program for 1983, results of sample analyses, and evaluation of the data with regard to applicable guides and standards. The reader is directed to the appendixes at the end of this report for detailed information concerning applicable guides and standards, quality control, analytical procedures, detection limits, error term propagation, and reporting of minimum detectable concentrations. Appendix D includes a discussion of the methodology used for reporting measurements that were at or below the minimum detectable concentrations (MDC). This appendix also discusses the use of the less-than sign (<) and defines the use of plus or minus (±) error terms in the data reported.

A. Airborne Effluent Monitoring

Production and research facilities at Rocky Flats are equipped with 43 ventilation exhaust systems. Particulates, generated by production and research activities are entrained by exhaust air streams. These particulate materials are removed from the air stream in each exhaust system by means of High Efficiency Particulate Air (HEPA) filters. Residual particulates in each of these systems are continuously sampled downstream from the final stage of the HEPA filters. For immediate detection of abnormal conditions, ventilation systems that service areas containing plutonium are equipped with selective alpha air monitors. These monitors are sensitive to specific radionuclides, including plutonium 239 and 240 and are tested and calibrated routinely to maintain sensitivity. The monitors alarm automatically if out-of-tolerance conditions are experienced. No such conditions occurred during 1983.

Three times each week, continuous particulate samples are removed from each exhaust system and are radiometrically analyzed for long-lived alpha emitters. The presence of long-lived alpha emitters is indicative of the effluent quality and the overall performance of the filtration systems. If the total long-lived alpha concentration for an effluent sample exceeds the Plant action guide value of 7.4×10^{-4} Bq/m^3 (0.020×10^{-12} μCi/mℓ), a followup investigation is conducted to determine the cause and to establish the need for corrective action..

At the end of each month, samples from each ventilation system are composited into a single sample for specific chemical analysis. An aliquot of each of the dissolved composite-samples from the 43 Plant exhaust systems is analyzed for beryllium particulates, using a flameless atomic absorption spectrometry technique.[11] The remainder of the dissolved sample undergoes chemical separation and subsequent alpha spectral analysis to quantify

*1 Sv (Sievert) = 1 J kg^{-1} = 100 rem.

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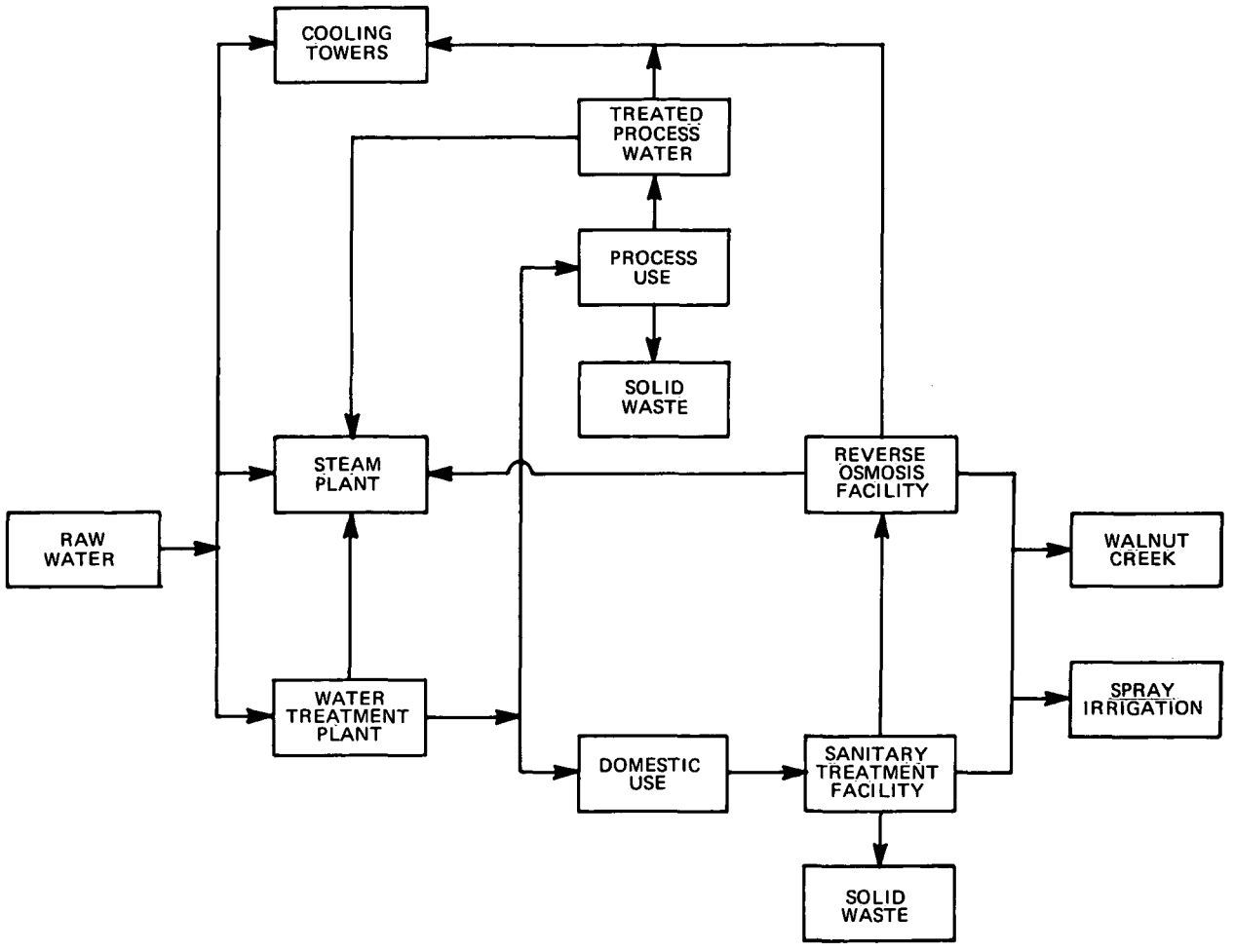

FIGURE 7. Water Use at the Rocky Flats Plant

The 1983 soil sampling program was conducted as part of a long-range program designed to study possible migration of plutonium in soil and to provide data for comparison with the EPA proposed guidance on transuranium elements in the environment.[5] Surface and core samples collected at one onsite location to support the plutonium migration in soil study showed values that are not significantly different from those reported in 1980, 1981, and 1982. To provide data for comparison with the EPA proposed guidance on transuranium elements in the environment, one onsite location was sampled. The median value from the site sampled was 0.4 percent of the EPA proposed guideline for plutonium in soil.[5]

The 1983 environmental measurement of external penetrating gamma radiation, using thermoluminescent dosimeters (TLD's), showed that the annual dose equivalents onsite, at the Plant perimeter, and at community locations, were within the range of regional background.

Potential public radiation dose commitments, which could have resulted from Plant operations, were calculated from average radionuclide concentrations measured at the DOE property boundaries and in surrounding communities. Dose assessment for 1983 was conducted for the DOE property (site) boundary, nearby communities, and to a distance of 80 kilometers (50 miles). At the Plant

Particulate and tritium sampling of building exhaust systems was conducted continuously. Emission data derived from analysis of plutonium and uranium samples were somewhat elevated compared to 1982 data. Overall, 1983 emission data were in the ranges projected in the Plant Impact Statement and presented no significant insult to the environment.

Particulate samples are collected from ambient air samplers operated continuously onsite, at the Plant perimeter, and in 13 community locations. The concentrations of airborne plutonium at all locations were far below applicable RCG's.[2,4] At the Plant perimeter and at the community locations, the 1983 average plutonium concentrations in ambient air were 0.02 and 0.04 percent, respectively, of the applicable DOE and Colorado Department of Health RCG's[2,4] and less than 0.7 percent of the proposed EPA guidance for plutonium in ambient air.[5]

During 1983, monitoring of ambient air for total suspended particulates (TSP), ozone (O_3), sulfur dioxide (SO_2), carbon monoxide (CO), nitrogen dioxide (NO_2), and lead was conducted utilizing a self-contained, mobile ambient air monitoring (MAAM) van. These six parameters are criteria pollutants regulated by the EPA and the State of Colorado through the Clean Air Act of 1970 that includes the National Ambient Air Quality Standards (NAAQS).[6] For TSP, the calculated annual geometric mean was 69 percent of the annual Geometric Primary Standard. The highest one-hour concentration of O_3 was 47 percent above the EPA Primary One-Hour Standard. This value was consistent with levels reported in the Denver Metropolitan area. For SO_2, the calculated annual arithmetic mean was 10 percent of the EPA annual mean standard. The maximum one-hour concentration of CO was 36 percent of the EPA Primary One-Hour Standard. Limited collection of NO_2 data indicated an arithmetic mean value that was 28 percent of the EPA annual mean standard. The quarterly lead concentrations measured during 1983 were all less than 3 percent of the EPA Quarterly Standard.

The majority of the water used during 1983 for Plant process operations and sanitary purposes was treated and evaporated and/or reused for cooling tower makeup, steam plant use, or for spray irrigation within the Plant boundaries. A schematic diagram of water use is shown in Figure 7.

Surface runoff from precipitation was collected by surface water control ponds. After monitoring, this water was discharged offsite. Those discharges were monitored for compliance with an EPA National Pollutant Discharge Elimination System (NPDES) permit.[7] During 1983, the Rocky Flats Plant met all requirements of the permit.

Routine water monitoring was conducted for two downstream reservoirs and for drinking water in nine communities. The average radioactivity concentrations for plutonium, uranium, americium, and tritium measured at these locations were found to be 1.7 percent or less of the applicable RCG's.[2,4] In addition, the sum of the average concentrations for plutonium and americium in all community drinking water samples was 0.05 percent or less of the State of Colorado regulations for alpha-emitting radionuclides[8] and the EPA National Interim Primary Drinking Water Regulations.[9] Average concentrations of tritium in community drinking water samples were all within the local background range and were 1.6 percent or less of the applicable State of Colorado and EPA drinking water standards.[8,9]

Groundwater monitoring was conducted four times during 1983 at 56 sampling locations. Tritium and uranium are present in low concentrations at monitoring wells close to solar evaporation ponds that have been used to store process wastewater. The concentrations of plutonium, uranium, americium, and tritium at all locations were well below the DOE and Colorado Department of Health RCG's for surface water discharged to uncontrolled areas.[2,4]

Biocides and herbicides are used for pest and weed control at the Rocky Flats Plant. Water samples collected during the period of application indicated concentrations of the chemicals well below recommended concentration limits. Also, polychlorinated biphenyl (PCB) monitoring showed no detectable concentrations above a detection limit of approximately one part per billion.

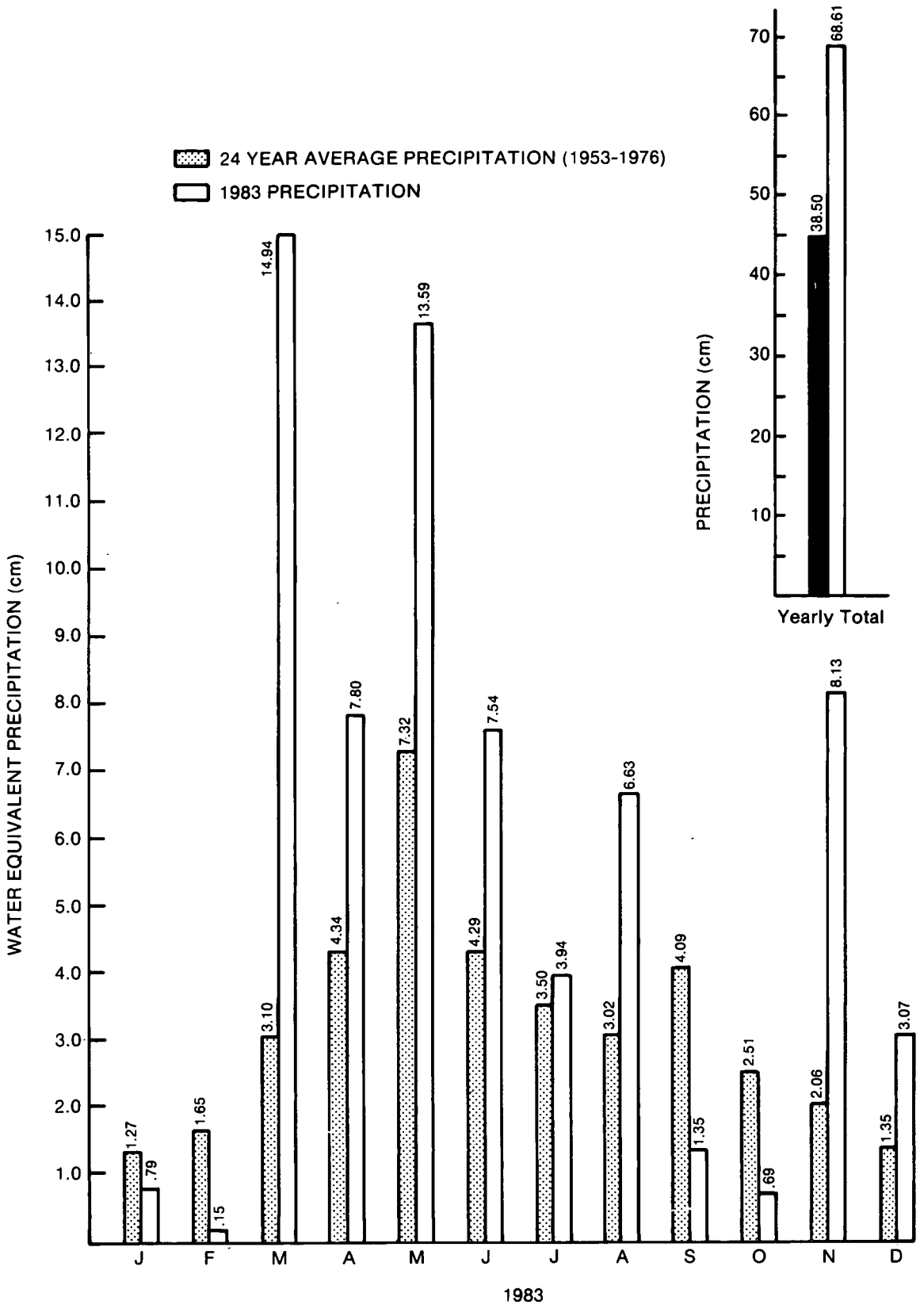

FIGURE 6. Monthly and Annual Water-Equivalent Precipitation at the Rocky Flats Plant

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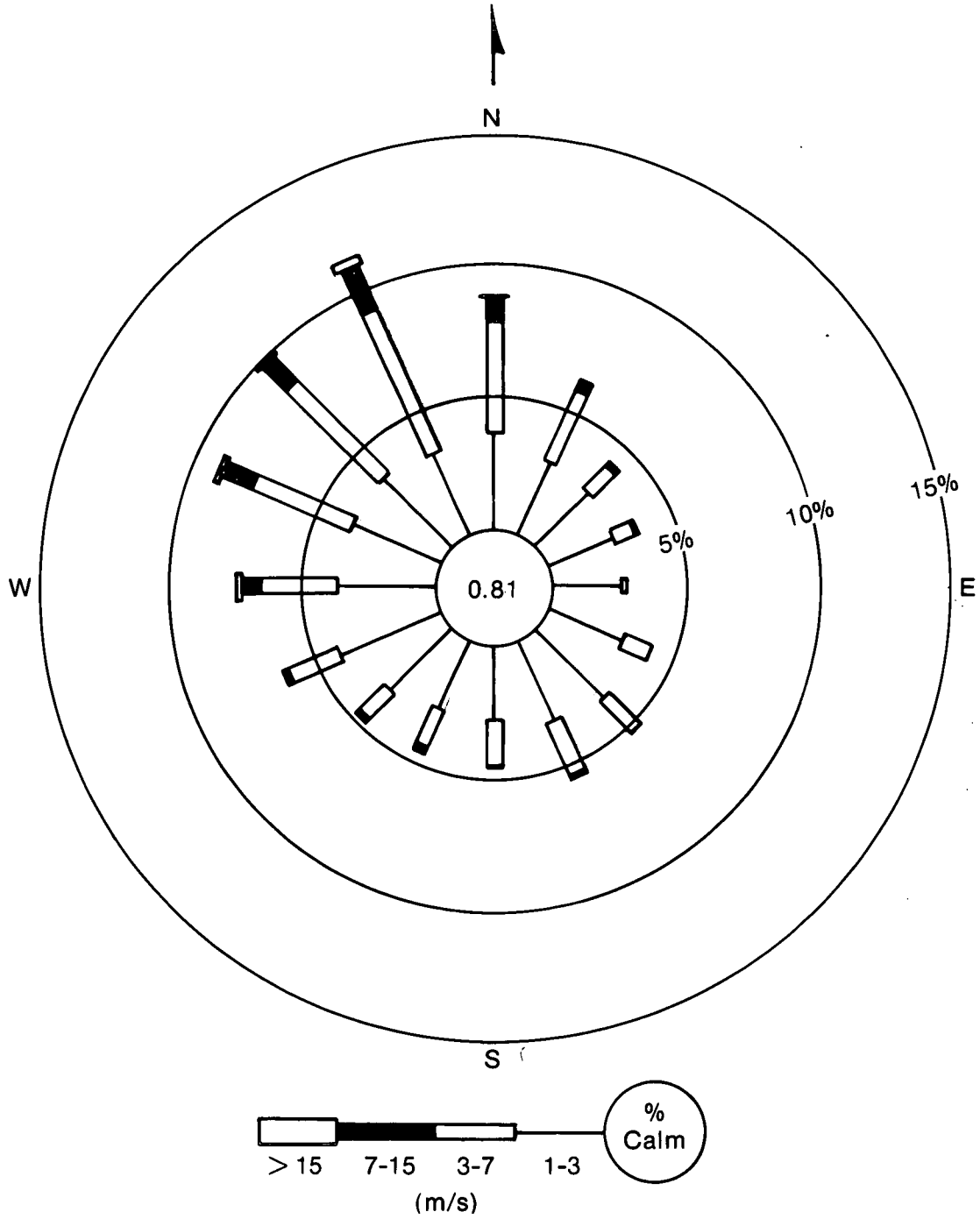

FIGURE 5. 1983 Annual Wind Rose for the Rocky Flats Plant

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Area Office, the Radiation Control Division of the Colorado Department of Health, Region VIII of the EPA, the health departments of Boulder and Jefferson Counties, and to interested city officials in communities near the Plant.

II. SITE METEOROLOGY AND CLIMATOLOGY

Wind, temperature, and precipitation data were collected on the Plant site during 1983. Table 1 is an annual summary of the percent frequency of wind directions (16 compass points) divided into four speed categories. The compass point designations indicate the true bearing when facing against the wind. These frequency values are represented graphically in Figure 5. The wind rose vectors also represent the bearing against the wind (i.e., wind along each vector blows toward the center). The predominance of northwesterly winds is typical of Rocky Flats. The low frequency of winds greater than 7 meters per second (15.6 mph) with easterly components is also normal.

Daily maximum and minimum temperatures were above normal during January and February, near normal in March, and below normal in April, May, and June. Temperatures were above normal from July through October, near normal in November, and below normal in December. Daily minimum temperatures were 0 °F, or lower, for 10 days during December. The annual average maximum and minimum for 1983 were near the 24-year average.

A summary of monthly water-equivalent precipitation is shown in Figure 6, along with the 1953-1976 monthly averages for comparison. Precipitation was below average in January, February, September, and October. Near normal precipitation was experienced in July. The remaining seven months showed above-average levels of precipitation. Values for March and November exceeded the monthly maxima for the 24-year climatological period. The annual precipitation of 68.61 centimeters (27.01 inches) was 78 percent above the 24-year mean of 38.50 centimeters (15.16 inches).

TABLE 1. Wind Direction Frequency (Percent), by Four Wind-Speed Classes, at the Rocky Flats Plant

(Fifteen-Minute Averages—Near East Gate—1983[a])

	Calm	1-3 (m/s)[b]	3-7 (m/s)	7-15 (m/s)	>15 (m/s)	TOTAL
-	0.81	-	-	-	-	0.81
N	-	3.55	4.36	0.78	0.01	8.69
NNE	-	2.93	2.82	0.38	0.00	6.14
NE	-	2.83	1.22	0.09	0.00	4.14
ENE	-	2.57	0.80	0.11	0.00	3.48
E	-	2.66	0.65	0.00	0.00	3.31
ESE	-	3.22	1.06	0.00	0.00	4.27
SE	-	3.85	1.73	0.00	0.00	5.58
SSE	-	3.42	2.06	0.04	0.00	5.52
S	-	2.92	1.67	0.04	0.00	4.63
SSW	-	2.95	1.55	0.06	0.00	4.55
SW	-	3.47	1.28	0.08	0.00	4.84
WSW	-	3.91	2.02	0.16	0.00	6.09
W	-	3.73	2.98	0.70	0.13	7.54
WNW	-	3.55	4.05	1.32	0.02	8.94
NW	-	3.68	4.76	1.34	0.13	9.91
NNW	-	3.61	5.91	1.79	0.26	11.58
TOTALS	0.81	52.82	38.92	6.90	0.55	100.00

a. Data obtained from sensors located ~10m (33 ft) above the ground.
b. For conversion purposes, miles per hour (mph) equals 2.237 multiplied by meters per second (m/s).

III. MONITORING SUMMARY

During 1983, the Rocky Flats Plant conducted an environmental monitoring program that included the sampling and analysis of airborne effluents, ambient air, surface and groundwater, soil, and vegetation. External penetrating gamma-radiation exposures were also measured using thermoluminescent dosimeters. The program consists of collecting samples at onsite, boundary, and offsite locations. Ambient air quality monitoring and monitoring of water for trace quantities of toxic materials, metals, nitrates, biocides, herbicides, and polychlorinated biphenyls also were performed. Specific details of the routine Rocky Flats Environmental Monitoring Program are documented in the "Catalogue of Monitoring Activities at Rocky Flats."[3]

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for evaporation and drying, and the salts are packaged and shipped to a DOE-approved storage facility.

Nonradioactive solid wastes are transferred to an onsite sanitary landfill for disposal. This landfill was designed and constructed in 1974 with an impervious clay seal layer and surface water diversion ditches. Routine materials are checked daily for radioactivity at the landfill site before final burial. The disposal of nonroutine or special nonradioactive waste materials is administratively controlled.

Groundwater and surface water flow, in and around the sanitary landfill, is controlled by interceptor trenches and by french drains. The trenches divert all upgradient waters around the landfill. The drains collect groundwater from the perimeter of the landfill and divert it around a holding pond. The holding pond collects subsurface drainage from the landfill. Water samples from this holding pond, the drains, and the three test wells in the vicinity are collected periodically and are analyzed for pollutants and radioactivity.

Land use at the Rocky Flats Plant is managed by Rockwell International for the Department of Energy. This includes land utilization planning and environmental and physical control of the land. All major activities conducted on Plant site land require approval by the Rockwell Executive Committee based upon recommendations of a Land Management Coordinator. The Coordinator evaluates all research projects and other nonroutine activities on Plant lands by means of a Land Use Request system. The effects of such activities are evaluated by Environmental Analysis personnel through field observations and remote sensing techniques.

Personnel in the Environmental and Occupational Health Branch of Rockwell International, conduct an extensive environmental surveillance program at the Plant. Environmental and Occupational Health personnel assist various operating groups in adhering to the DOE policy that ". . .operations shall be conducted in a manner to assure that radiation exposure to individuals and population groups is limited to the lowest levels technically and economically practicable."[2] This surveillance program is designed to provide assurance that the many safeguards at the Plant effectively limit the release of radioactive or toxic materials. The results of the program indicate that effluent treatment and control processes at the plant were effective during 1983.

The environs are monitored for ionizing radiation and for pertinent radioactive, chemical, and biological pollutants. Air, water, soil, and vegetation are sampled on the Plant site and throughout the surrounding region. Several Federal, State, and local governmental agencies independently conduct additional environmental surveys on and off the Plant site. The Colorado Department of Health samples air, soil, and water at the Rocky Flats site and in surrounding communities. It also operates an onsite, continuous, particulate air sampler for the Jefferson County Health Department. The DOE Environmental Measurements Laboratory (EML) has conducted particulate air sampling at the Rocky Flats Plant and periodically performs special studies, including sediment and soil analyses. Additional special analyses have been performed by the U.S. Environmental Protection Agency (EPA).

Plutonium concentrations in this report represent the alpha radioactivity from plutonium isotopes 239 and 240, which constitute over 97 percent of the alpha radioactivity in plutonium handled at the Plant. Reported uranium concentrations are the cumulative alpha activity from uranium 233, 234, and 238. Components containing fully enriched uranium metal are handled at the Rocky Flats Plant. Depleted uranium metal is fabricated and also is handled as process waste material. Uranium 235 is the major isotope by weight (93 percent) in fully enriched uranium; however, uranium 234 accounts for approximately 97 percent of the alpha activity of fully enriched uranium. In depleted uranium, the combined alpha activity from uranium 234 and 238 accounts for approximately 99 percent of the total alpha activity. The Radioactivity Concentration Guides[2] (RCG's) used in this report for uranium in air and water are those for uranium 233, 234, and 238, which are the most restrictive.

The information contained in this report is submitted in compliance with Department of Energy Order 5484.1, Chapter IV and is a compilation of data provided monthly to the DOE Rocky Flats

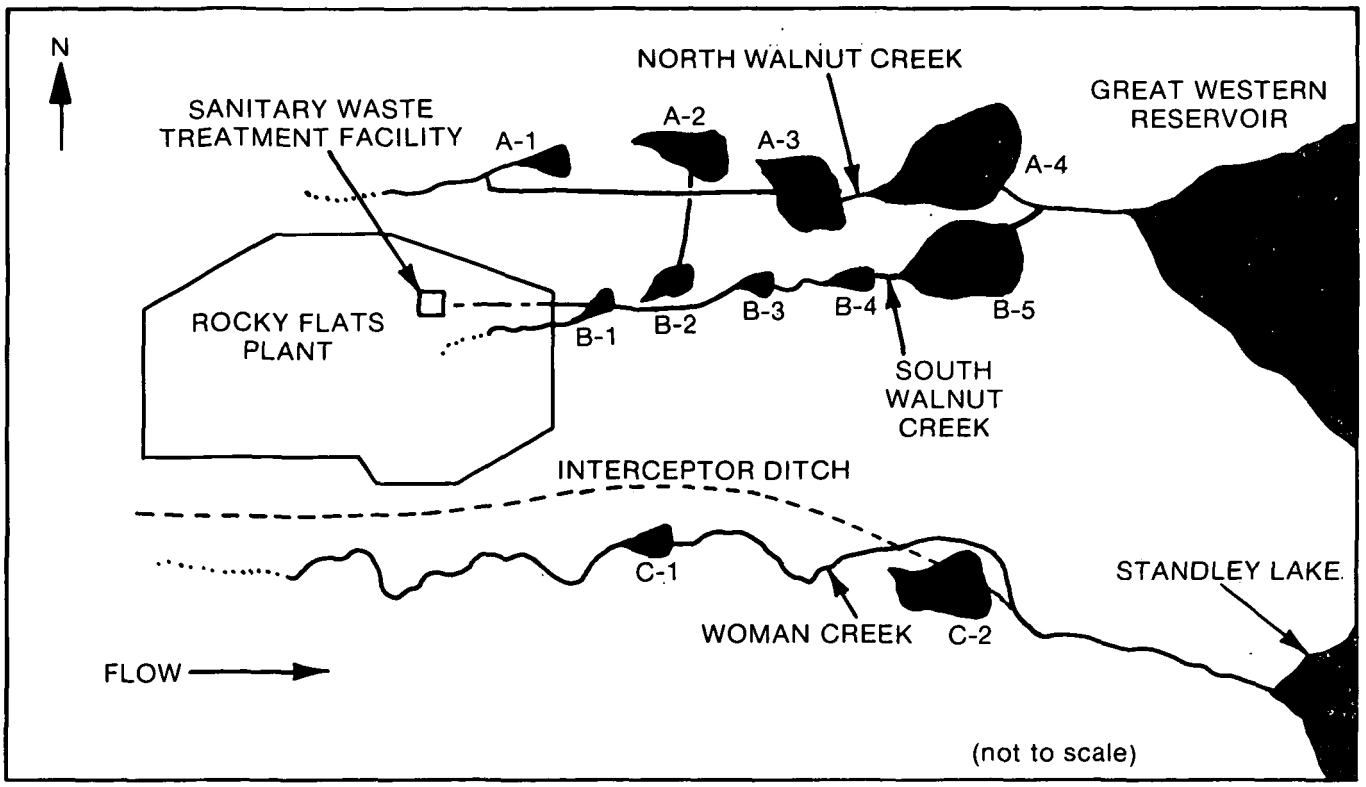

FIGURE 4. Holding Ponds and Liquid Effluent Watercourses

radioactive materials. Radioactive materials are handled in accordance with stringent procedures and within multiple containments (physical barriers) designed to minimize the release of contaminants to the environment. The radioactive waste systems include collection, filtration, liquid processing, and temporary storage facilities for those process wastes known, or suspected, to have been in contact with radioactive materials. The liquid waste process system concentrates liquid wastes containing unrecoverable radioactive materials into solid wastes suitable for shipment, along with other contaminated solid wastes, to a DOE-approved storage facility. Specific details of Plant waste processing facilities are described in the Rocky Flats Plant Site Final Environmental Impact Statement.[1]

Sanitary waste is processed by the sanitary waste treatment plant and is isolated from process waste throughout the Plant. Conditioning chemicals are added to destroy biologically degradable organic wastes. The treatment plant is of the activated sludge type and has three stages of treatment. It has a design capacity of 1,700,000 liters (450,000 gallons) per day. Present daily flows usually vary between 570,000 and 950,000 liters (150,000 and 250,000 gallons) per day. One of two 265,000-liter (70,000-gallon) preaeration holding tanks, located upstream from the sewage plant, serves as a surge basin to smooth out peak flows. A second holding tank provides storage capacity for sanitary wastes should emergency retention be required. Liquid effluents from the sanitary waste treatment plant can be released to Walnut Creek, released to holding ponds for subsequent onsite irrigation, or pumped to a reverse osmosis facility for further treatment. After treatment, product water from the reverse osmosis facility can be recycled for use in Plant cooling towers, or spray irrigation, or may be released to Walnut Creek.

Residual solids from the sanitary waste treatment plant are concentrated, dried, packaged, and shipped to a DOE-approved storage facility. Reverse osmosis brine is sent to process waste treatment

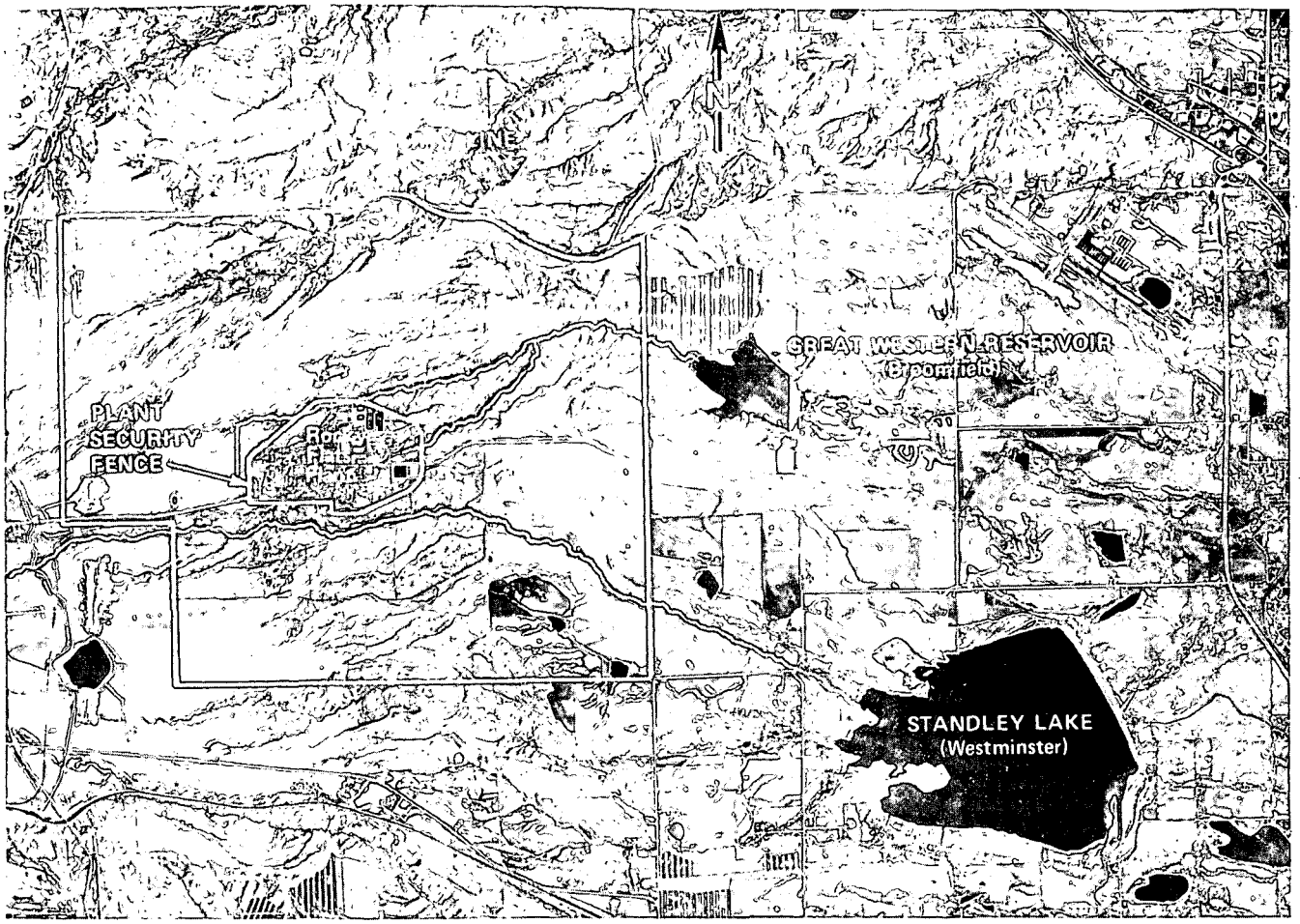

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FIGURE 3. Aerial Photograph of the Rocky Flats Plant and Immediate Vicinity

specified filtration efficiency standard of 99.97 percent for 0.3-μm particles. Prior to installation in the filter plenums, each filter is tested at the Plant to ensure that the filtration efficiency is not less than the standard. Airborne radioactivity released to the environment from process operations is kept to a minimum and is well within Plant health and safety guidelines.

As shown in Figure 4, surface water runoff from the Plant is from west to east. Runoff is carried from the Plant by three major drainage basins that are tributary to Walnut Creek on the north and to Woman Creek on the south. The south fork of Walnut Creek receives most of the stormwater runoff from areas surrounding Plant buildings.

Also shown in Figures 3 and 4 is the confluence of the north and south forks of Walnut Creek which is 1.1 kilometers (0.7 mile) west of the eastern perimeter of the Plant. Great Western Reservoir, a water supply for a part of the City of Broomfield, is 1.6 kilometers (1 mile) east of this confluence. Woman Creek flows east from Rocky Flats into Standley Lake, a water supply for the City of Westminster and for portions of the cities of Northglenn and Thornton. Ponds on the north fork of Walnut Creek are designated A-1 through A-4. Ponds on the south fork are designated B-1 through B-5. These ponds receive runoff and/or treated sanitary wastewater. Pond C-1 is located on the Woman Creek watercourse. Pond C-2, located near the Woman Creek watercourse, receives surface runoff water from an interceptor ditch parallel to the south side of Plant production areas.

Certain operations at the Rocky Flats Plant involve or produce liquids, solids, and gases containing

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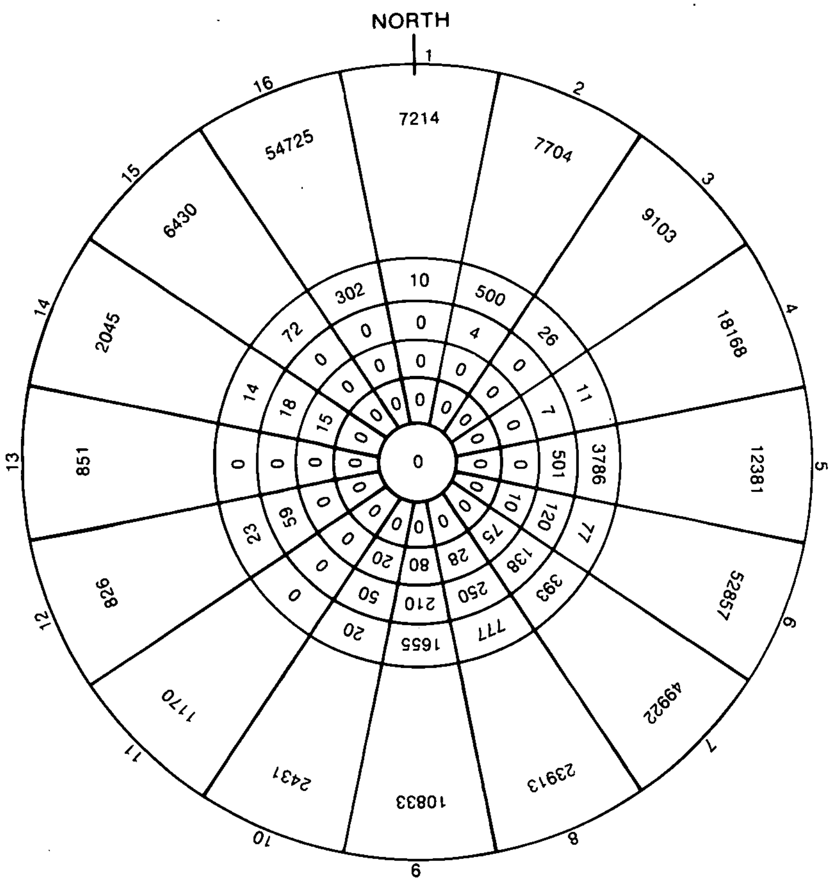
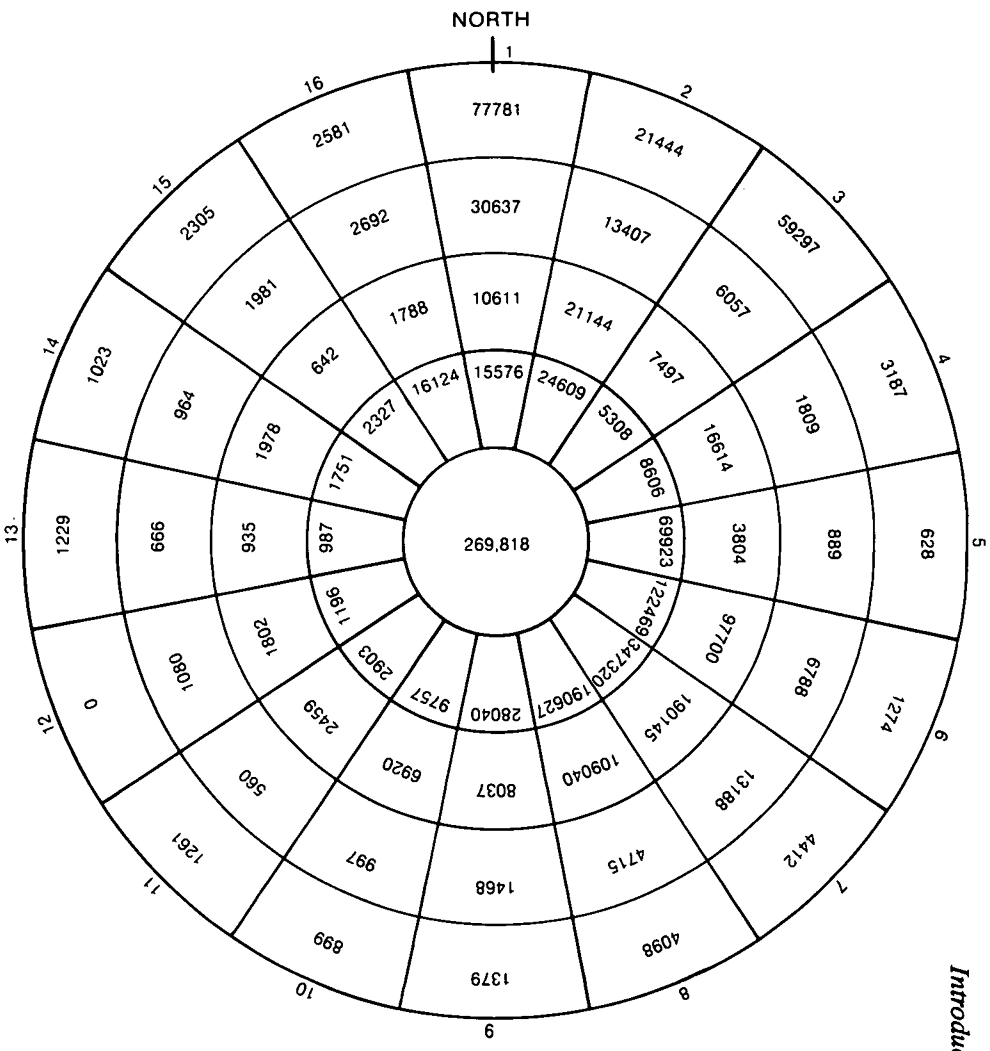
FIGURE 2. Demographic Estimates - 1980[a]



0-16 Kilometers (0-10 miles) From Rocky Flats[b]



16-80 Kilometers (10-50 miles) From Rocky Flats[c]

a. These population estimates (0-16 kilometers) were calculated from 1980 Census Tract Data, assuming even population distribution throughout the sector.

b. Concentric circles represent 1-to-2, 2-to-3, 3-to-4, 4-to-5, and 5-to-10-mile mileage bands.

c. Concentric circles represent 10-to-20, 20-to-30, 30-to-40, and 40-to-50-mile mileage bands.

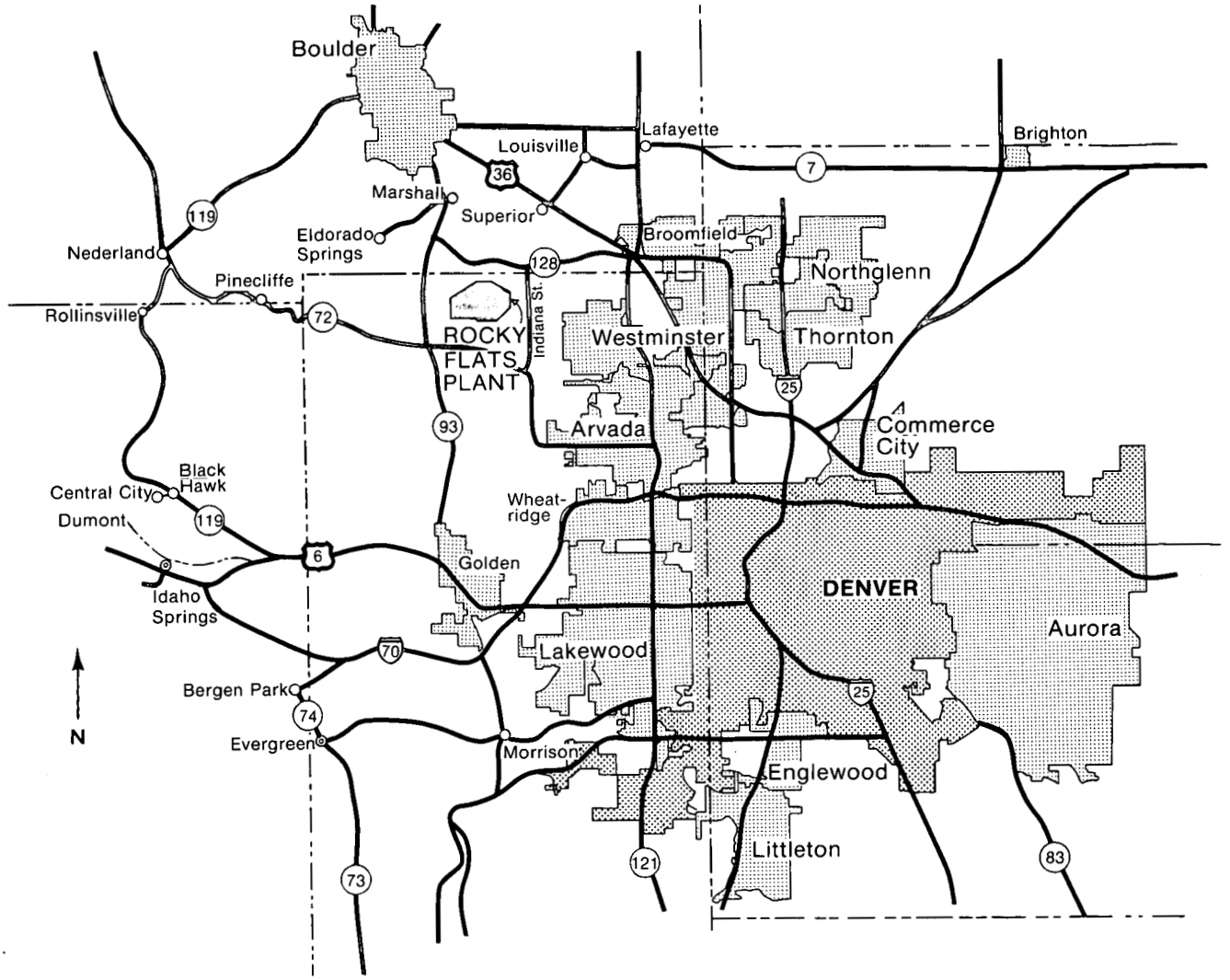


FIGURE 1. Area Map of Rocky Flats Plant and Surrounding Communities

There is considerable clear-sky sunshine, and the average precipitation and relative humidity are low. The elevation of the Plant and the major topographical features of the area significantly influence the climate and meteorological dispersion characteristics of the site.

Winds at Rocky Flats, although variable, are predominantly northwesterly, with stronger winds occurring during the winter. During 1983, approximately 53 percent of the winds had a westerly component.

Annual average precipitation at the Rocky Flats Plant is slightly over 38.5 centimeters (15.16 inches). The maximum annual precipitation recorded over a 24-year period (1953-1976) was 63.17 centimeters (24.87 inches) in 1969. The annual precipitation during 1983 was 68.61 centimeters (27.01 inches). This exceeded the previous maximum. Typically, more than 80 percent of the precipitation falls as rain between April and September. Most of the remaining precipitation is in the form of snow.

Air in production and research facilities is continuously discharged to the atmosphere by 43 ventilation exhaust systems. Prior to atmospheric discharge, the exhaust air passes through particulate filtration systems. These filtration systems employ High Efficiency Particulate Air (HEPA) filters that are purchased to equal or exceed the DOE

ANNUAL ENVIRONMENTAL MONITORING REPORT
U. S. DEPARTMENT OF ENERGY, ROCKY FLATS PLANT
January Through December 1983

I. INTRODUCTION

The Rocky Flats Plant is a government-owned and contractor-operated facility. It is part of a nationwide nuclear weapons research, development, and production complex administered by the Albuquerque Operations Office of the U.S. Department of Energy (DOE). The prime operating contractor for the Rocky Flats Plant is the Energy Systems Group of Rockwell International.

The Rocky Flats Plant is located at 105°11'30" west longitude and 39°53'30" north latitude in northern Jefferson County, Colorado. The Plant is approximately 26 kilometers (16 miles) northwest of downtown Denver and is almost equidistant from the cities of Boulder, Golden, and Arvada (Figure 1). Demographic estimates for 1980 are shown in Figure 2. There is a population of approximately 2 million within the 0 to 50-mile radius of the Plant. The Plant site consists of 2,650 hectares (6,550 acres) of federally owned land. As shown in Figure 3, major Plant structures are located within a security-fenced area of 155 hectares (384 acres).

The Plant is a key DOE facility that produces components for nuclear weapons; therefore, its product is directly related to national defense. The Plant is involved in fabricating components from plutonium, uranium, beryllium, and stainless steel. Production activities include metal fabrication and assembly, chemical recovery and purification of process-produced transuranic radionuclides, and related quality control functions. Research and engineering programs supporting these activities involve chemistry, physics, materials technology, ecology, nuclear safety, and mechanical engineering.

The more than 100 structures on the Plant site contain about 189,000 square meters (2.03 million square feet) of floor space. Of this space, major manufacturing, chemical processing, plutonium recovery, and waste treatment facilities occupy about 156,000 square meters (1.68 million square feet). Major laboratory and research buildings occupy about 13,850 square meters (149,000 square feet). The remaining floor space is divided among administrative, utility, security, warehousing, storage, and construction contractor facilities.

All of the Plant's heating requirements are met by in-plant steam boilers that normally use natural gas and are capable of using fuel oil. During Calendar Year 1983, approximately 19.8 million cubic meters (699 million cubic feet) of natural gas were used. No fuel oil was used during 1983.

Raw water is purchased from the Denver Water Board and is drawn from Ralston Reservoir and the South Boulder Diversion Canal. The Rocky Flats Plant used approximately 416 million liters (110 million gallons) of water during 1983.

The piedmont of the Front Range of the Rocky Mountains rises 8 kilometers (5 miles) west of the site and crests at the Continental Divide, which is 32 kilometers (20 miles) from the Plant. The natural environment of the Plant site and vicinity is influenced primarily by the Front Range of the Rocky Mountains and the site elevation, which is 1,829 meters (6,000 feet) above sea level. The surficial geology of Rocky Flats consists of a thin layer of gravelly topsoil underlain by a 6- to 15-meter (20- to 49-foot) thick layer of coarser, clayey gravel. This is underlain by an impermeable bedrock structure upon which Plant building foundations are supported. Area hydrology is influenced by the topsoil, which consists of gravelly and highly permeable alluvium. Water retention in the soil is poor, and vegetation in the area is sparse. Cactus, spanish bayonet, and grasses representative of a mixed short- and mid-grass plain, constitute the main ground cover. Introduced Eurasian weeds also make up part of the flora. Cottonwood trees grow adjacent to watercourses.

The climate at Rocky Flats is characterized by dry, cool winters and warm, somewhat moist summers.

ABSTRACT

This report documents the environmental surveillance program at the Rocky Flats Plant, as conducted by the Environmental Analysis Section of the Environmental and Occupational Health Branch. Sample analyses are performed by the Health, Safety, and Environmental Laboratories of the Health, Safety and Environment Department and by the General Laboratory of the Quality Engineering and Control Department. This report includes an evaluation of Plant compliance with all appropriate guides, limits, and standards. Potential public radiation dose commitments were calculated from average radionuclide concentrations measured at the Plant property boundaries and in surrounding communities. Comparisons with appropriate guides, limits, and standards and with background levels from natural or other non-Plant sources, provide a basis for concluding that no adverse environmental effects were attributable to the operation of the Rocky Flats Plant during 1983.

CONTENTS

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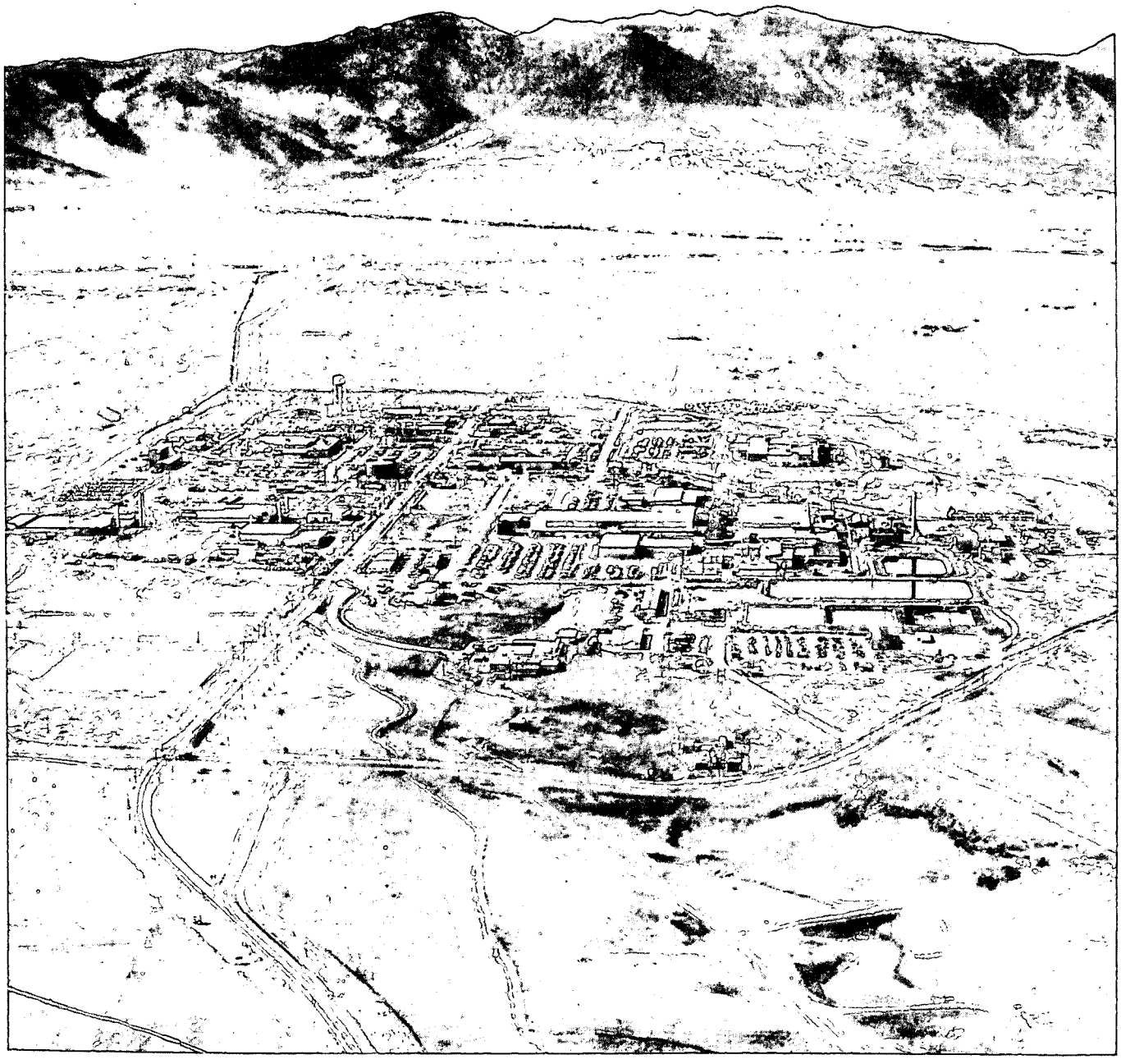

ROCKY FLATS PLANT VIEWED FROM THE EAST 24151-13A

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ANNUAL ENVIRONMENTAL MONITORING REPORT
U. S. DEPARTMENT OF ENERGY, ROCKY FLATS PLANT

January Through December 1983

ENVIRONMENTAL ANALYSIS SECTION

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